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APRIL 28, 29, 30, 1941

ADDRESS OF THE PRESIDENT

MARS AND ÆSCULAPIUS*

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BOSTON, MASS.

ON THIS ROSTRUM, a Fellow of the Association has stood each year since its founding and tried to find words adequately to express his feelings. Let each of my hearers put himself in my place, which he may sometime occupy, and think what he could say to make known at once his pride and sense of personal inadequacy in justifying the honor conferred upon him. He would find, as do I, that mere words cannot avail.

During the threescore years of our existence as an Association, for but one period—if we except the skirmish of 1898—have we faced war. In 1916, goaded by insults to our national sovereignty and moved by deep sympathy for the allied nations attacked by a common enemy, we stood on the brink of war, which prompted Le Conte to make his eloquent appeal for preparedness, medical as well as military. In 1917, committed to war but, under the protection of our sore-pressed Allies, feverishly preparing and still not actively engaged, Mixter, describing the war as conservative since it must be waged in the defense of humanity, pointed out its analogy to the duty required of those who must remain at home, to conserve and defend the high standards of sur-

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gery. In 1919 and 1920, Pilcher and Brewer described the influence of war surgery on civil practice and discussed the methods and steps by which civilian surgeons could be trained and organized for military needs and with Lund, in 1930, recounted the record of our Association and of the profession at large in the First World War. It is worth repeating. Of our Fellows, 83 per cent volunteered, among them 25 of the 33 Senior Fellows of an average age of 70. Ninety-four of the 116 commissioned officers were of field rank, and there were received 22 decorations and ten citations. Of the 14,358 medical officers who went overseas, 68 were killed in action or died of wounds, 212 survived wounds, 11 were missing in action or lost at sea. These surgeons and physicians of America, who volunteered or were drafted from civil life and, confronted by unaccustomed problems, made grievous mistakes and achieved glorious triumphs, as did their fellows in the line, like them, paid the price.

With our weight tilting the scale the war was won but the peace, it seems, was lost, for now, scarcely a score of years later, we stand again at the gates of Armageddon. Our idealism in undertaking to ensure the future of Democracy by waging a war to end war has become a mockery. The same enemy confronts us, his purpose far more sinister, his strength vastly augmented by the devotion of the whole wealth and power of a great nation to the sole purpose of ruthless aggression, his resources multiplied by those of peace-loving, terrorized, conquered peoples; his mailed fist supported by allied ghouls whose nostrils tell them—falsely to be sure—of the expected kill. More dangerous is he because of his strength, but also because of the doctrine with which he has inoculated the people—a doctrine at once ludicrous, absurd but dreadful in its evil intent, of a superior race predestined by the Creator to prosper at the expense of all other peoples. This foe is bending all the agencies of the physiochemical and psychologic sciences to his purpose and showers death in its most ghastly forms on man, and destruction on the monuments of his civilization, to a degree which is callously designed to involve a nation in its totality if it refuses to submit. Gone or nearly so, on his part at least, are the mitigations of the so-called rules of war, the chivalries of equal combat among men. The unarmed, the defenseless, the weak, the aged, the young of either sex have no privilege of even partial exemption, but rather suffer the more because they have not the strength for self-defense. And standing rock-like against this monstrous, reckless, merciless destroyer stands the English-speaking Island Empire and her overseas' daughters, shorn by enemy subjugation of all her Allies save one, asking us to consider whether a precarious freedom can be enjoyed alone in case of her defeat.

In the face of this chaos of material destruction and of spiritual degradation, of bleeding bodies and of hating souls one wonders whether we live in an ordered world, where war is really an inevitable and perhaps a desirable condition. This viewpoint is found in the writings of social and moral philosophers from the beginning of recorded history to the present, and we are only too familiar with their pronouncements. Karl von Stengel, a German jurist who, in odd contradiction to his views, was a delegate to the first Hague Peace

Conference, says: "War has more often facilitated than hindered progress . . . great States like Germany and Italy are welded into nationalities only through blood and iron; . . . storm purifies the air and destroys the frail trees, leaving the sturdy oaks standing; . . . War is the test of a nation's political, physical and intellectual worth." von Moltke wrote: "A perpetual peace is a dream and not even a beautiful dream. War is one of the Elements of order in the world established by God; the noblest virtues of man are developed therein." Ernest Renan declares: "War is one of the conditions of progress, . . . it compels satisfied mediocrity to awaken from its apathy." And Theodore Roosevelt declared: "By war alone can we acquire those virile qualities necessary to win in the stern strife of actual life." Curiously enough a pacifist, upholding the moral over the natural law, may reach the same decision as the militarist. Thus Edward Grubb says: "Self-preservation is not the final law for nations any more than for individuals; . . . the progress of humanity may demand the extinction of the individual, and it may demand also the example and the inspiration of a martyr nation." It is not vouchsafed to us to make authoritative pronouncement on the validity of these views; each of us is guided by his experience and by his study of the humanities and of science. One concept, however, seems worth considering: If the existence of man upon this planet is counted back by tens of thousands of years to the Quarternary Period, or by hundreds of thousands of years into the Tertiary, it cannot be doubted that science has caused more fundamental changes in the conditions of his life in the last hundred, nay even the last fifty years, than occurred in the entire antecedent period. Perhaps the moralities based on the *mores* of the past are no longer tenable in a mechanized world.

We are on safe ground, however, if we affirm that the art and science of medicine throughout recorded history, has found opportunity for development in war—a development which also has found its application in peace. To go no further back than 800 B.C. we find a clinical observer named Homer, in a communication which he called the Iliad, describing in the ten-year contest between the well-greaved Greeks and the horse-taming Trojans on the plains of Troy, no less than 147 wounds by spear, sword, arrow, and slings which showed a mortality of 77.6 per cent. The army surgeon most often mentioned was Machaon, for when the Trojan Pandarus broke the truce by wounding Menelaus in the shoulder with an arrow, Agamemnon sent his Herald for "the hero Machaon, son of the blameless physician Æsculapius," who, having extracted the arrow head, "sucked out the blood and skillfully sprinkled on the wound soothing remedies." This was some 25 centuries or more before the Geneva Convention so that the Medical Corps were not protected by the Red Cross (nor are they now, 77 years later under the usages of totalitarian warfare); so it appears that the surgeons spent their spare time in combat, for Homer tells us that "Paris, the husband of fair-haired Helen, disabled Machaon, the Shepherd of the people performing prodigies of valor, wounding him on the right shoulder with a triple-barbed arrow." Idomeneus then prevailed on Nestor to carry Machaon from the fight in his armored chariot.

"For," said he, "a medical man is equivalent to many others, both to cut out arrows and to apply mild remedies."

Progress and indeed change of any sort were conspicuous by their absence through succeeding centuries, but always the wars furnished the school of experience for surgeons. Five hundred years after the sack of Troy, the Father of Medicine, Hippocrates said: "He who would become a surgeon therefore should join the army and follow it." Through the classic days of Greece and Rome, through the intellectual and cultural gloom of the Middle Ages, the thousand years between the downfall of the Western and of the Eastern Empires, most of the time under the domination of the Galenic tradition, the art of medicine progressed but little and science not at all. Printing was invented but found at first no scientific gospel to spread abroad; the advent of gunpowder and firearms modified the tactics of warfare and the nature of wounds; the mariner's compass helped bring the questionable blessings of European civilization to aboriginal and pagan peoples. The physician of the period was attached to the persons of feudal overlords and princes, the practice of surgery was relegated to barber-surgeons, incisors, tooth extractors, and quacks who ministered alike to soldiers and the common herd. There was little to suggest the near approach of the rediscovery of Greek culture and the activities of the dormant genius of western Europe, especially of Italy, which we call the Renaissance.

Modern science properly begins with Copernicus, who founded modern astronomy, and with Vesalius, author of the greatest medical book ever written, in a century which sparkles with great names in art, literature, philosophy, and medicine. Ambroïse Paré, "unquestionably the greatest surgeon of the Renaissance" gained an experience in the army of Francis II which led him to revolutionize the treatment of wounds, already modified by Paracelsus. On a certain battlefield, having exhausted his supply of "scalding oyle of Elders with a little Treacle mixed therewith" with which in accordance with tradition he cauterized the supposedly poisoned gunshot wounds, he substituted a bland "digestive made of the yolke of an egg, oyle of Roses and Turpentine" and, having passed a night sleepless with anxiety, found those thus treated comfortable, well-rested, and with noninflamed wounds, which made him resolve "never again to cauterize any wounded with gunshot." He further avoided unnecessary surgical trauma by reviving the ligature as a substitute for cauterization to arrest hemorrhage. Vesalius was a military surgeon under Charles V and may well have been inspired by the surgical problems of the battlefield to study and to teach anatomy. The same source may have supplied him with material for dissection. Harvey, whose demonstration of the circulation of the blood, and researches in anatomy, microscopy, and chemistry were the beginning of modern experimental physiology, served in the army, as did many of the greatest physicians of the seventeenth century—Descartes, Willis, Sydenham, Wiseman. This was an era of frightful epidemics of bubonic plague, typhus, dysentery; devouring famine stalked in the train of constant warfare; the Germanic states were all but ruined by the Thirty Years War.

Prostitution was rife in the armies. Physicians and surgeons had problems enough with practically no scientific knowledge to aid them. The eighteenth century was an age of artificiality and gross materialism peopled by those, in Carlyle's cynical phrase, "whose souls were extinct but stomachs well alive."

In a period of formal theories and systems, nevertheless, clinical advances of extraordinary significance were made: The therapeutic use of digitalis by Withering; the discovery of percussion by Auenbrugger; the introduction of the pulse-watch and of clinical thermometry; the harnessing of electricity for electrotherapy by Volta, Galvani and Franklin; the creation of immunity by inoculation with a kindred but harmless disease by Jenner which conferred on man the power, not always utilized, alas!, of controlling if not eliminating an ubiquitous and fatal pestilence. The provision of adequate care for troops became a definite function of government, and the camp and the battlefield continued to be the great practice schools for surgeons. Wound treatment became simpler, and apparently empiric observation prompted the use of antiseptic dressings long before Pasteur and Lister demonstrated microbic organisms, for we read of the packing of wounds with lint moistened with brandy, corrosive sublimate, balsam of Peru, tincture of myrrh, camphor, and turpentine. John Hunter's commanding figure dominates the surgical stage, and we must believe that much of his experience was gained as a military surgeon and finally as surgeon-general of the British Army; for the list of his chief contributions—the nature and treatment of shock, phlebitis, intussusception, chancre, chancroid, aneurysm, dental diseases, inflammation, and gunshot wounds indicate the source of much of his clinical material, which his use of the experimental method and knowledge of pathology made the establishment of surgery as a branch of scientific medicine. The development of surgery in America was promoted by the experience of the Revolutionary War, in the work of Morgan, Shippen, Rush and Warren; the first American Pharmacopeia was prepared for the use of the Continental Army by Dr. William Brown, and the first book on surgery published in America was a Treatise on Wounds and Fractures by Dr. John Jones in 1776. To the end of this century and the beginning of the next belongs the amazing Larrey, surgeon-in-chief of the Grande Armée, participant in 60 battles and 400 engagements of the Napoleonic wars, originator of systematic first aid to the wounded, who advocated débridement and was adjudged to be worth in his own person a division of troops.

With the nineteenth century we are reaching modern times, where we can better realize the conditions attending the care of troops. Of all wars up to that time, the Crimean War of 1854–1855 is said to have had the greatest teaching value in military medicine. Its success was nearly wrecked by utterly inadequate sanitary and supply service. In the combined British and French forces, four times as many men died from disease as from enemy action and the French suffered the highest recorded mortality rate from disease—253 per 1,000. Conditions at the base at Scutari were indescribably bad. Soldiers

ill and dying of cholera, typhus, dysentery, and scurvy were crowded together with the wounded and the less seriously ill, without beds, often without bedding, without proper sanitary arrangements and supplies and without any epidemiologic precautions. There were no nurses. These scandalous conditions created indignation in England which resulted in the dispatch of a young woman, who was advocating the training of women for nursing services, Florence Nightingale, with a score of volunteers. The story of her wellnigh magical transformation of pest houses into hospitals, of utter hopelessness into sanguine resolution is one of the most stirring epics of our race. In a futile and disastrous war a modest worker found the opportunity to create one of mankind's most blessed institutions, modern trained nursing. In our own War between the States were created for the first time organized ambulance corps and mobile field hospitals under canvas, and the importance of the medical corps in military campaigns was recognized by giving its officers increased rank and authority. Da Costa, Weir Mitchell, and Keen found their opportunity in the special military hospitals established for the treatment of cardiac, pulmonary, and nervous diseases. It has been said that American neurology sprang from the war and grew up in the army. The experience in surgery gained by thousands of army surgeons who returned to civil life tended to improve the level of practice in the community. Although the first official record of a military medical nature was published by the British Government after the Crimean War, the six volumes entitled The Medical and Surgical History of the War of the Rebellion constituted a most important contribution to military medicine and set a worthy standard of attainment. The Franco-Prussian War of 1870 proved incontestably the importance of the elaborate sanitary preparations which were made by the Germans; among their forces for the first time in history the battle losses exceeded the deaths from disease; the incidence of and deaths from smallpox among the incompletely vaccinated French prisoners were five times those of the efficiently protected Germans. Lister's new antiseptic method first published in 1867, which was bitterly opposed by most of the British profession outside of Scotland, was eagerly adopted by German army surgeons under the leadership of Volkmann, Mikulicz and Thiersch and passed this searching test successfully. Our skirmish with Spain in 1898 brought out in high relief that epidemics may be more serious than battles, for then, probably for the last time in history, typhoid fever exacted its dreadful toll by causing most of the 3,450 deaths from disease, contrasted with the 559 deaths from enemy action. The Boer War but two years later was the occasion of the first use of antityphoid vaccination on a scale large enough and with sufficient success to justify its general adoption. The Russo-Japanese War demonstrated anew the overwhelming value of carefully organized sanitary measures in maintaining health and morale before battle, and the possibilities of a highly developed field ambulance and first aid system supplemented by mobile hospitals in saving lives which would otherwise be lost by delay.

The First World War was remarkable and unique in its mobilization and use of every branch of science and of art on a scale never before attempted, primarily in the production and perfection of engines of war and the training of men to use them, and secondarily in measures to maintain the morale of troops, prevent epidemic sickness, and get wounded men back on the firing line as quickly as possible. The improvement in wound treatment is shown by the fact that in our Civil War the mortality among wounded men who reached an hospital was 10.5 per cent and in the World War it was reduced to 4.5 per cent; nor does this tell the whole story because the highly fertilized soil of France and Belgium was reeking with pathogenic organisms of all sorts, especially gas-forming anaerobes and tetanus bacilli which impregnated the uniforms of men caked with the dirt and mud of trench warfare. All the world knows of the researches of the English chemist Dakin and our own Carrel in developing the efficient method of wound disinfection which bears their name, the similar employment of eusol introduced by Smith, and the bismuth-iodoform-paraffin paste of Rutherford Brown. The more or less forgotten wound excision practiced a hundred years before by Larrey was revived as the modern débridement. The prompt reduction and immobilization of fractures was aided by reviving and popularizing the Thomas type of splint and the Balkan frame. The return to active duty of 70 per cent to 80 per cent of all nonfatal casualties in two months or less is eloquent testimony to the efficacy of these methods. Important studies of shock were made by Porter, Crile, Cannon, and others, and though the last word is still to be said on this subject, a standard and relatively satisfactory method of treatment was proposed and adopted. In England, Starling and Hill worked on the problems of asphyxiation by war gasses, Mott studied shell shock, Lewis unraveled the mystery of neurocirculatory asthenia. In France, Marie studied injuries of the central and peripheral nervous systems and contributed to an understanding of their pathologic physiology. When wounds of certain regions were found to create special problems, as in the case of the cranial cavity and its contents, of face and jaws, of the thorax, they were gathered so far as possible into the hands of specialists who were enabled by the study of so many cases to formulate important principles of treatment. Never was such opportunity given to practice the plastic and reconstructive repair of ghastly disfigurements, or to restore to relative usefulness, at least, shattered bones and disorganized joints. The success of the sanitary measures taken both on the battle fronts and in cantonments constitutes one of the greatest triumphs of medical sanitary science. Preventive inoculation rendered harmless smallpox, typhoid fever, tetanus, diphtheria, and even the dysenteric diseases. The control of the vermin-borne diseases, typhus and trench fever, was accomplished by the adoption of a method of de-lousing which approached a science in its exactitude. The incidence of meningitis was lowered. There remained, however, problems still unsolved—influenza, pneumonia, measles, mumps, scarlet fever, and venereal diseases took their inevitable toll. The total deaths from disease in our forces were 50,174. Had the rates prevailing in our Civil War

been the rule, the figures would have been 227,094, or four and one-half times greater. It is tempting to mention those of our Fellows, indeed those of the Allied Forces, whose share in these triumphs of healing and sanitation were most conspicuous, but it might seem invidious when each played faithfully his appointed part as far as he was able, according to his opportunity.

In the interval of time since the First World War was ended by a premature armistice, the experience which it afforded has been reviewed, analyzed, evaluated, and applied to the needs of everyday life. The internecine war in Spain has supplied the opportunity for further clinical experiment, of which the most striking development has been in the treatment of wounds, especially compound fractures. The Carrel-Dakin and similar methods involving frequent irrigation, laborious and often painful dressings, the saturation of plaster fixation molds, and the inevitable interruption of treatment during transportation, constituted a great advance over many other antiseptic methods at the expense of serious difficulties of execution. Orr's personal experience of these difficulties and his study of the factors involved in the healing of infected wounds led him to adopt the method now widely known by his name, foreshadowed by Ollier of Lyon, by Lister himself, and by others, but perfected and brought to the somewhat incredulous attention of the medical world by an American surgeon. The method, which will be presented and discussed at our symposium, has achieved such amazing results in the hands of its advocates that it may constitute a revolutionary improvement in the treatment of certain classes of wounds.

Epidemiology and preventive medicine have steadily advanced. Tetanus and diphtheria will be all but abolished by immunization by toxoids. Pneumonia and epidemic meningitis, hitherto unsolved problems, are having their mortality rate cut in half and again in half by chemotherapy. Gonorrhea is aborted by the same means. For typhus and influenza there is as yet no dependable immunizing agent, but sanitary control is increasingly effective. The importance to war industries of the health of the workers has led to the intensive study of industrial hygiene; the diseases due to dust of various sorts, to lead and its compounds, to volatile organic solvents, to radiation, to welding and metallurgic processes, to the manufacture of nitro-explosives—all these and many more are yielding to control to a degree which is of greatest importance in civil life. Anxious study is being devoted to the serious functional disturbance caused by the conditions attending war aviation—anoxemia, low pressure, extreme cold, terrific speed with sudden variations as in dive-bombing and unprecedented nerve strain. It has been stated that in the First World War of every 100 pilots killed, two died as the result of enemy action, eight from defective equipment, and 90 from defects in themselves, which means in the majority of instances fatal disturbances of normal physiology. The relative importance of the various elements in the treatment of shock is being tested, especially the use of plasma preserved in various ways and even of an artificially prepared plasma as a substitute for whole blood. The rôle played by vitamins in nutrition and the provision of vitamin-protected foods

to support maximum physical effort is being investigated on an unprecedented scale. Unlimited material for the study of the neuroses is at hand.

Unquestionably, the conditions attending war offer opportunities for gaining knowledge which is of permanent rather than of emergency value. As Lord Horder expresses it: "War is an evil thing, but has done good, like a hormone, in activating the whole chemistry of the Nation." Regarded philosophically, it illustrates the unsolved paradox of human behavior, that the same intelligence should invent and cherish the things which safeguard, enrich, and beautify life, and permit their use to disfigure, degrade, and destroy it. It is said that in the sixteenth century the average duration of a human life in western Europe was 19 years; in the eighteenth century it had lengthened to 32 years; now it is 62 years, and this has been accomplished by the same intellectual processes of observation, experimentation, research, and judgment as were employed in the First World War to maim or slaughter 30 million human beings. The same chemists working in the same laboratory may synthesize elements to make tri-nitro-toluol to destroy life and a sulfonamide compound to save it. The same mechanical device operating on the same physical principles is used, as Doctor Fosdick says, to point a telescope at a constellation or to aim a siege-gun at a sleeping city. Science is accused of prostituting herself for ignoble and despicable ends—it is not Science herself but her generously bestowed gifts to Man which he chooses thus to employ. "It is clear," says Charles Seymour, "that the crux of the problem confronting us is the proper application of science to life."

It is probable that when major disasters threaten the world, as when Attila and his Huns, and later Jenghis Khan and his Mongols, swept over most of western Europe, the civilized world must have felt that the supreme crisis was at hand and that civilization hung in the balance. May it not be that at the present moment—18 months after the outbreak of the Second World War—we are facing the most fearful crisis of all? When Homer sang of Troy, there sat upon the summit of Olympus aegis-bearing Zeus, with his staff of lesser gods: his consort, large-eyed Juno, far-darting Apollo, spear-brandishing Minerva, laughter-loving Venus, and the renowned artificer, Vulcan. They were quite human in their attributes—these gods; they loved and quarreled, laughed and wept, and knew the quality of mercy, and the nature of their guidance of men upon the earth below mirrored these qualities. Nigh 3,000 years have passed, Zeus is dethroned and there stands upon Olympus a sinister figure wearing as insignia a twisted cross—a figure cruel, ruthless, savage, yet armed with every weapon of destruction provided by enlightened science and industry. The satellites about him are but slavish executives of his evil will. Twenty nations and principalities cower and bleed beneath the rain of fire and steel which he has loosed and not one small voice among the mighty people whom he rules cries out in shame and protest.

Again Britain and her daughter nations, bleeding but with heads unbowed, stand against this monstrous thing. Again America is moving to their side;

again the weight of her power will press down the scale-pan wherein lie liberty and justice. When the victory shall be won, let our care be that mankind shall also win the peace by lavishing on its nurture something of the same energy, treasure, and self-sacrifice which is poured into the lap of Mars.

SURGERY AND THE SULFONAMIDES

THE practical problems of surgery that come up in connection with the use of these drugs can for the most part be solved by keeping in mind the pathology of the process under treatment and relating the pathology to the mode of action of the sulfonamide compounds.

In the first place, a contaminated wound, a compound fracture, or a wound resulting from a colon resection is a fresh wound with an amount of necrotic tissue in it which varies with the nature of the wound, the effectiveness of débridement in that wound, and the duration of the wound after the trauma. The presence of sulfonamide inhibitors is usually low in these wounds, and, therefore, sulfanilamide therapy is particularly effective in preventing the outgrowth of the contaminating organisms in these wounds. We are tending, most generally, to use sulfanilamide as the drug of choice in wound prophylaxis of this sort, partly because we feel that in general it is a little safer than the other sulfonamides. We do not get the kidney complications that can occur with sulfathiazole, and, for the time being, we are tending to stick to sulfanilamide in this particular prophylactic use. Later on there may be reason to change, but for the present I think sulfanilamide is the drug of choice. In such traumatic wounds, infection can be prevented either by the administration of the drug by mouth or by introducing the drug locally into the wound either in the form of crystals or in the form of solutions. The high concentrations which can be obtained with local application will tend to prevent the outgrowth of types of bacteria such as staphylococci which might be resistant to the smaller concentrations obtainable with oral administration.

There is no reason yet to believe, however, that the local implantation or application of sulfanilamide in such wounds should be used as a substitute entirely for the systematic administration.

I will not attempt to go into the chemistry of these sulfonamide inhibitors except to say that they are at present in very high concentration in products of tissue necrosis. Any infection which brings about an extensive degree of tissue breakdown or digestion or necrosis, whatever you want to call it, results in enzymatic degradation of the tissue and liberates a large amount of these sulfonamide inhibitors, which will in turn prevent or tend to prevent the effective bacteriostatic action of the sulfonamides.

Some aspects of this subject of the mode of action with sulfonamides are still in a state of controversy. We all tend to have our own ideas, and I feel myself that not every point in my own hypothesis has been established beyond question.

—John S. Lockwood, M.D., Phila.,—Round Table Conferences on Recent Advances in Chemotherapy, Pennsylvania Medical Journal, 44, No. 5, 580-592, 1941.

SURGICAL PROBLEMS OF THE WAR*

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Medical Organization.—The medical organization for this war has been devised on different lines from that of the last, and it has succeeded well in its task. Although some of its anticipations have proved incorrect, it has coped satisfactorily with many problems unexpectedly introduced by new methods of warfare. The policy adopted was the formation of the Emergency Medical Service under the Ministry of Health for the whole country, with central and local advisory committees composed of medical men, and this undertook the care of the whole civilian population, and the treatment of service casualties and wounded. Apart from this, the military forces retained their own hospitals, and in addition have their own medical services in use and in training according to their war establishments.

Before war actually started, the medical profession had been voluntarily conscripted, and this work was undertaken by the British Medical Association for the Ministry of Health. Every member was card-indexed and his wishes for service consulted, so that from this pool the B.M.A. is able to satisfy any demand of the State by way of personnel in and for every purpose.

Hospital Organization.—The hospital policy was based upon the expectation of very large numbers of air raid casualties, a sound calculation which fortunately has not so far been fulfilled. Consequently, a large number of beds were provided in the countryside, outside the large cities, and the medical staffs and equipment were spread out fanwise to form new units in what are termed "Sector Hospitals." In these areas, special hospitals with appropriate staffs were organized for dealing with special kinds of wounds. To each of these hospitals, blood transfusion units have been attached and stored blood provided.

Evacuation.—Not since the times of the plagues in the seventeenth century, even including the time of the Armada in Elizabeth's reign, about 1588, had the population of London moved from its ancestral home. The exodus was like the journey of the children of Israel and the enemy failed to pass the narrow waters of the Channel. In September, 1939, nearly three-quarters of a million people were moved, including children, families, the aged, defectives, and incurables—true a small part of this widespread and gigantic city—and the remainder grimly took to the task of going to ground for cover. A vast array of new organizations sprang up from nowhere, A.R.P. services, auxiliary fire service, police wardens, ambulance units, and

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women driver fire spotters, decontamination squads, stretcher parties, first-aid stations, rationing, feeding, and clothing centers, but the average Londoner went about his daily business with a grim determination and an eye cocked up to the skies. A few sirens (popularly known as "Moaning Minnies") greeted the first few days of the war, then silence, and many people came back to town. France capitulated, and we were uneasy. Then in July, 1940, the Teuton fury crashed with all its might upon our ancient monuments. Tiny silver fish whirling in and out of the summery smoke-trailed skies were a daily sight and the bag began to mount like a cricket score. Then came the bomber for several nights with droning monotony and crashing of bombs without reply. Suddenly our anti-aircraft guns began to roar. The wakeful Londoner took a new hope and found soothing slumber and comfort in the sound of their noise. Now the bomber may sneak over at night and we almost miss his visits in the day time.

However, in spite of this upheaval the health of the community has been very good. There have been no epidemics and the only complaint has been an increase in the number of skin cases due to scabies, impetigo, and pediculi, and, strangely, the town children have shown less strain than those evacuated.

WAR WOUNDS

General.—In general, it may be said that the surgical principles laid down for wound excision in the last war have again proved sound, and the chief change has been the adoption of the Winnett Orr method based on the experience gained in Spain, and the use of sulfonamides for combating infection. The consensus of opinion is that the combination of these three methods has proved of great benefit in the treatment of war wounds. To the wounded, this closed method has proved a great boon, and eliminates many of the difficulties in transport, for it gives the maximum of comfort. On account of its objectionable smell, it is hoped that it does not remain the final solution to the problem of war wounds in general, but it is a distinct advance on the constant irrigation and the painful and repeated dressings of the open method employed in the last war. Where these methods have been employed, the wounded have arrived back in good condition and the wounds have been clean. Their morale after a good rest was very high. This is a war of quick motion and there is little of that demoralizing delay which sapped the courage and spirit of the men from the trenches. Of these two new methods, the closed plaster encasement has at present certainly come to stay, but with regard to sulfonamides it must be remembered that these compounds are still in the experimental stage, and it is perhaps too early to assess them at their true value.

Special Wounds and Injuries.—Although the number of wounded so far has not come up to expectation, that a good many are mortal is evidenced by the low percentage of abdominal and chest wounds treated in hospitals in comparison to the more numerous wounds involving the limbs.

The modern high explosive aerial bomb is more destructive than maiming, and its dangers may be briefly summarized as follows:

(1) Those due to direct hits.
(2) Blast.
(3) Crush injuries from fallen masonry.
(4) Burns.
(5) Splinter wounds from bomb casing and glass.

These are dealt with under their regional headings. Splinter wounds are common and multiple, the patients are dirty and often present the appearance of Egyptian mummies (Fig. 1). After explosion, the bomb cas-

FIG. 1.—Multiple wounds. December 6, 1940. (Courtesy Surgeon Rear Admiral Cecil P. G. Wakeley.)

FIG. 2.—Multiple wounds (same case as Fig. 1). December 14, 1940. (Courtesy Surgeon Rear Admiral Cecil P. G. Wakeley.)

ing bursts into small hot fragments which spread out fanwise in a horizontal direction with low trajectory. Splintered glass is commonly sucked outward and injures people in the streets (Fig. 2). These casualties require careful examination for several days. In the early stages, they may be too shocked to cooperate, and even after excision of their wounds it is surprising to find the number of nerve lesions which have been missed. Venous thrombosis is apt to follow these wounds from infection driven into superficial veins.

Airmen are particularly liable to burns, especially those of the hands and face, and this has involved changes in the design of their craft. In the Navy, the incidence of burns is also high. Depth charges are apt to cause rupture of the colon and retroperitoneal hematoma, in men swimming on the surface, and, in ships which have been mined, such curiosities as complete

dislocation of the knee, butterfly fractures of the upper end of the femur, and compressed fracture of the spine have been noted.

Surgical Experience in the B.E.F.—In order to get a comprehensive idea of the management of war wounds, it is necessary to recapitulate the routine adopted at the front as given by Max Page. Every man received two doses of tetanus antitoxoid with T.A.B., and the low incidence of tetanus, even in the presence of the relatively few grossly contaminated wounds, emphasizes the wisdom of this measure. Although gas gangrene serum was available, it was not systematically employed. The chief aim is to get the wounded to the nearest surgical unit within 12 hours, and in these days of mechanized and aerial warfare this ideal is more likely to be attained. Fortunately, the extensive and mutilating wounds from shell and mortar have been less in evidence now than in the 1914–1918 war.

With regard to sulfanilamide, this was employed in two ways, prophylactically and into the wound, either by mouth starting with an initial 2 Gm. dose followed by 1 Gm. four-hourly up to 20 Gm., or by direct insufflation into the wound in doses varying from 5 to 20 Gm.

In the hospital the primary factors are the control of hemorrhage and the treatment of shock, either primary or secondary, by means of rest, warmth, and morphia and transfusion if necessary. It is only then that exicision is carried out. The principles involved here are the removal, not too wide of the skin, and of all devitalized muscle and fascia, the aim being to obtain a clean shelving wound suitable for drainage. With excision, sulfanilamide, and plaster encasement, the results are good. This gives the maximum of comfort to the patient, but he requires careful and continuous watching with special regard to edema of the toes, pain, pulse, and sleep.

The more urgent indication for early excision are those wounds of entrance only involving fleshy parts, with retained missiles. In the case of multiple wounds, the larger ones only should be excised, as also those wounds complicated by fracture or involvement of joints. In late wounds, after two to three days, infection has already taken place and formal excision is not indicated. Sulfonamides here may be given by mouth before operation, which consists of opening up the wound to provide free and dependent drainage, removing necrotic muscle or retained missiles, introducing sulfanilimide powder and packing with vaselined gauze and then plaster encasement. On the other hand, Wakeley and the Haslar school say that with wounds three days old from Dunkirk, excision, sulfonamides by local application, and suture and plaster encasement gave good results. With these general principles in mind, let us proceed to review briefly some main points involved in the regional surgery of the body.

Although primary suture for wounds up to 12 hours has been reported with successful results, the general impression is against this procedure.

Head Injuries.—The principles of the treatment of the wounds have been laid down by Cairns of the Oxford school, and by Jefferson, and are fundamentally the same as were followed in the last war.

(1) To remove infective material and dead brain tissue.

(2) Remove blood clot, extra- or subdural, and aerocele.

(3) Because of the danger of epilepsy, to consider whether retained foreign bodies should be removed.

Devitalized scalp should be excised and the wound edges closed in two layers, the galea and skin, using thread, after dusting with sulfanilamide. This may be done up to three days or even longer. But, the important criterion is whether the wound is penetrating or not, that is, whether the dura has been opened, and every means must be taken to establish this fact. When the dura is opened, damage to nervous pathways, spread of infection to the ventricles, and basal cisternae, and, later, the occurrence of abscess and the possibility of epilepsy must be borne in mind. The dural wound should not be enlarged unless the surgeon is prepared to remove necrotic brain tissue and clot in order to prevent tension, otherwise herniation of the brain will develop. Forcible irrigation and suction are employed for this, and at the same time all dirt, foreign bodies, and detached bone must be removed.

In penetrating or tangential wounds, the bone may be nibbled away, or an osteoplastic flap may be raised. The advocates of the latter method claim better access and reduced infection. The general impression is that repair of the dura is unsafe and tension and herniation can be controlled by repeated lumbar puncture. Gaping wounds may have to be left open unless they can be closed by means of a sliding skin graft. Missiles within the brain are usually left alone, but if the clinical signs and protein content of the cerebrospinal fluid increase, bold measures must be taken for their removal.

There is a definite impression that sulfonamides, either by mouth or intravenously, delay the necessity of operation, and tend to localization of infection within the brain and that these abscesses can be excised *in toto* with their capsule at a later date.

With regard to signs and symptoms, concussion in head wounds is as a rule slight, or absent, in contrast with civil injuries. On the other hand, unconsciousness may occasionally occur late and be prolonged. Again, focal symptoms are more frequent than in civilian injuries. They have a strong tendency to undergo spontaneous recovery, and operation is indicated only when they come on late. By means of ventriculography, cases are being separated into those with good and bad prognosis.

Abdomen.—Two per cent of all wounded. Mortality high.

In these remarks I have been helped by Rear Admiral Gordon Taylor, and quote freely from his notes and his book on Abdominal Injuries in Warfare, which is a classic.

So far, in this present conflict the abdominal surgery of warfare has seemed conspicuous by its absence rather than its frequency. The paucity of the lesions of the belly produced by enemy action, which are not beyond all surgical aid, must have impressed

those observers whose sphere of surgical activity in the Franco-British Casualty Clearing Zone 20 odd years ago furnished them with an abundant experience of operative aid for those soldiers who were suffering from wounds in the abdominal area. In the past 20 months during which the writer has had the fortune to make official contact with hospitals along a considerable length of our coastline and some of the corresponding hinterland the numerical disparity between the operations performed for abdominal injuries by one surgeon on the British front in France a quarter of a century ago and the total aggregate attained in this campaign by many operators, mostly working in England, has been impressive. . . .

The "time-lag" between the hour of wounding and the possibility of expert surgery in a suitable environment plays the most important part in determining the fate of all abdominal casualties who are not immediately killed. The time factor may be inevitably protracted to the grave disadvantage of the patient by intervening expanse of sea or air. Nevertheless in army warfare a prolonged "time-lag" should not be so inevitable or capricious, save in circumstances of retirement, for hospitals reserved for the treatment of abdominal and other cases of "first urgency" may be made so mobile that they can be kept within the permissible "time-lag" despite the rapid movements which nowadays characterize war. This practice was employed with equal success in the Republican Army in Spain as the "Three-Point Forward System," the disposition of which aimed at ensuring the transference of the abdominal casualty to a No. 1 Hospital of urgency within six hours. The casualties admitted to such a hospital included:

(1) Wounds with severe hemorrhage—including all cases in which a tourniquet had been applied.
(2) Abdominal wounds.
(3) Severe chest wounds, especially cases of open pneumothorax.
(4) Some head wounds.
(5) Any case in which there was gross destruction of tissue or grave shock.

Major Douglas Jolly found that almost 20 per cent of the admissions to such a hospital were abdominal injuries and the recovery rate of those submitted to operation compared most favourably with the figures of abdominal surgeons in the last Great War. There was, therefore, no paucity of abdominal admissions or operations in open warfare in Spain, but the projectiles responsible for the injury were bullets and artillery shells in about 75 per cent of the cases in the series quoted.

It is manifestly impossible to maintain forward hospitals for an Army falling back. All patients operated before the break-through must be evacuated to the rear, and for the more recently wounded, little more than first aid treatment is possible before evacuation. Under such conditions, the percentage of abdominal wounds who survive is scarcely likely to be high; nevertheless, abdominal cases did survive in the retreat of Gough's Fifth Army, in March, 1918. . . .

In our Army, series of cases collected during the Dunkirk retreat and evacuation, the proportion of those wounded in the abdomen who received treatment, not necessarily operative, to the total casualties reaching medical units was about 4 per cent. This figure is smaller than the 6.4 per cent in the Official History of the Great War which was based on a certain series of 43,840 cases and is also less than Bashford Dean's estimate of 5.1 per cent. This recent series, however, is a very small one, and the paucity of cases may make any statistical comparison unreliable.

Instances are certainly known to me of abdominal cases operated upon in France and embarked at Dunkirk and other French ports who completed their recovery in England; for example, Major Underwood had a remarkable series of successful abdominal cases in Flanders. . . .

The conveyance of wounded in ships across the seas carries added dangers. Abdominal casualties during transport across the Channel have shared with others in hospital ships a second horror from deliberate bombardment of the Red Cross, for these

outrages perpetrated 20 years ago by the Boche apparently are as naturally repeated by their Nazi sons. In 1918, an Australian officer who had a segment of small intestine resected for injuries due to high-explosive and whose abdomen had been closed by through-and-through sutures was immersed in the water as a result of the torpedoing of the hospital ship *Warilda*. He was dragged by a rope on to a destroyer and was fortunately little the worse for the adventure. In this war, the chances of recovery of an abdominal case from such an outrage have been prejudiced by the employment of air-bombardment of wounded men in the water, a practice which has been indulged in by the Hun even upon his Italian allies, and few that had already been wounded in the abdomen can have survived.

(1) Immersion in the sea after shipwreck has, on occasion, been associated with a novel intestinal lesion. Severe injury and even subparietal rupture of the large bowel without breach of skin may be received by men in the water from the detonation of depth-charges. Some have been successfully dealt with by primary operation; in others, a contused colon has permitted the permeation of organisms, and a subsequent abscess and even a fecal fistula have resulted. Others suffering from this form of violence have evidenced severe meteorism associated with an increase of temperature and pulse-rate which occasioned anxiety, but have fortunately recovered without more serious incident; in such, the diagnosis between contusion of the colon and some retroperitoneal injury or hematoma must remain a doubt.

Several causal factors appear to have determined this infrequency with which surgery has been successful, possible, or even worthy of any consideration for those wounded in the abdomen in this present conflict; these mainly concern victims of air-attack on this country. . . .

(2) The annihilation of distance and of the time-element by a well organized transport service in towns subjected to the indiscriminate air-bombardment of "total warfare" obviously counts for much in saving the lives of those injured in the abdomen for whom recovery is still possible, but the very measure of expedition with which the casualties reach the hospital doors will in its turn tend to overwhelm the surgeon with hopeless cases. . . .

(3) The severity and frequency of crush injuries of the trunk, including the abdomen, has been a feature of casualties on the "Home-front." Nonpenetrating injuries of the abdomen and its contents played a relatively small part in the abdominal surgery of the last war; this time civilians, women and children of tender years, and even the unborn babe are suffering crush contusions from falling masonry and from burial under collapsed houses and dwellings. Fragments or masses of wood, stone or metal may be confusedly hurled with devastating force against the abdomen; severe visceral damage or retroperitoneal hemorrhage may be produced by "blast" without any external evidence of injury. The abdominal parieties may suffer along with the subjacent organs and effusions of blood may be encountered in any of the layers superficial to the peritoneum. Actual rupture of the abdominal musculature along with visceral injury was infrequent in the last war; the blow that ruptured the powerful abdominal muscles became too spent to damage the intestinal tract. The increase of destructive force nowadays destroys and damages without fine anatomical distinction.

(4) Multiplicity characterizes the wounds and damage sustained from air-bombardment; not only is the mortality raised by lesions of many viscera, but many, even most of the regions of the body may be simultaneously damaged. The bespattered trunk and limbs in those who had been wounded by high explosives were familiar to surgeons in the last war, but the phenomenon is far more frequent in this conflict, and the severity of the concomitant injuries renders the prognosis of many an abdominal case hopeless.

(5) Some of those injured in the abdomen may also suffer from burns of the body or limbs. This complication of abdominal injury may be encountered in ships, or on shore; the prognosis will obviously become far more grave in such cases.

(6) The degree of shock encountered among the casualties of this war far transcends

that with which surgeons were familiar between 1914 and 1918. Despite the elaborate and highly organized resources of our transfusion services, despite the transfusion of many pints of blood or plasma, despite the administration of oxygen and all the resources of resuscitation therapy many of those wounded in the trunk remain in a condition of shock which precludes all thought of surgical interference.

In 40 per cent of the experimental animals examined there were hemorrhage lesions in various abdominal organs; all these cases exhibited pulmonary hemorrhages, also the abdominal organs appear to be less sensitive to blast than the lungs. The organ most frequently damaged by blast in the abdomens of experimental animals is the large intestine (Fig. 3); patches of hemorrhage may be found varying from punctate spots under

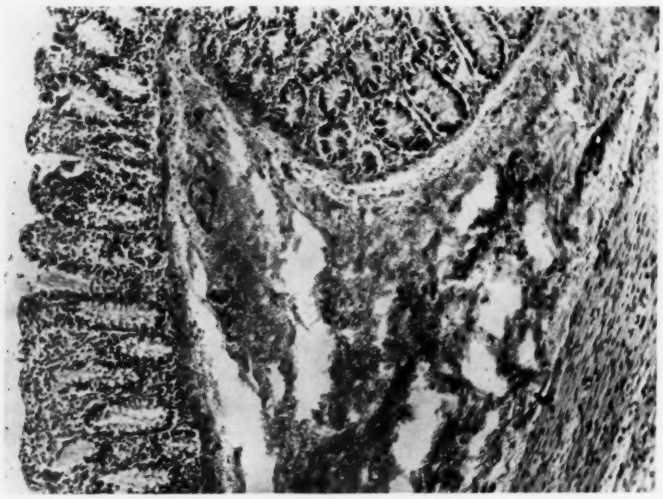

FIG. 3.—D. B., age 19. Blast injury to sphenic flexure. September, 1940. (Courtesy Rear Admiral Gordon Taylor.)

the serous coat to large annular bands of hemorrhage and even rupture. The small bowel is less frequently affected, as is the stomach. The liver may be bruised or torn or the right lateral surface may be diversified by lines corresponding to the ribs. The spleen, kidney and bladder are less often implicated. Blood-clots have been found in the peritoneum, and retroperitoneal hematomata may be found, as well.

The direct effects of blast are experienced only when close to the explosion, but there are many indirect effects which may produce death or serious injury.

The technic of the operative surgery for the repair of abdominal injuries sustained through enemy action seems unlikely to undergo any iconoclastic change in this war. The missiles of the foe may differ in character and in the relative frequency with which they are employed when comparison is made with the usage of the last Great War, but the controversy upon abstention or intervention for abdominal wounds which had occupied the minds of military surgeons so long was settled forever in 1915 by the pioneer work of Owen Richards and the staunch support and enthusiasm of Sir Cuthbert Wallace. . . .

It was far otherwise in the German Reich; across the Rhine there was nothing unrehearsed, nothing unconsidered by those responsible for the medical arrangements of the Nazi War-Machine. As far back as 1934, Waldman, Surgeon-General in Chief of the German Army in the last Great War, suddenly published a paper on the war-surgery of that campaign. Any reader who takes the trouble to glance through German periodical medical literature from that time onwards will find lengthy, comprehensive contributions on war-surgery written by some of the foremost surgeons of the Reich—

Borchard, Schmieden, Kirschner, Posner, Heinrich Schum, *etc.** Were these articles fortuitous in their publication? Was the recurrent theme a mere chance? Was the present construction of the new Hospital at Heidelberg a freak of the architect, with its enormous moiety underground and its capacious lifts for rapid evacuation of patients to its nether-portion of the Hospital? It becomes difficult to divorce Aryan medicine and surgery from the same bloody-mindedness that we associate with everything connected with the Nazi regime. The mendacious ululations of Goebbels and all the lying propaganda directed towards repudiating the war-guilt of Germany and placing it on other shoulders are refuted as surely by the medical history of Germany for at least five years before the outbreak of War as by the exploits of those Hun and Italian airmen over Republican Spain who used the cities of the Iberian Peninsula with helpless men, women, children and babes as practice-ground for future exploits already envisaged. . . .

The implications seem obvious in the case of the abdominal wounds of war. The local application of sulfanilamide powder to the abdominal wound will prevent the infection of the latter, and the introduction of sulfanilamide in saline into the peritoneal cavity and possibly the application of the powder to the sites of injury or repair may improve the prognosis.

In cases where there is injury to the retroperitoneal tissues or psoas muscle the local application of the drug is of great importance. Zinc peroxide has also been enthusiastically praised for lesions in this area, and may be perhaps profitably employed.

The present war has provided an opportunity for the employment of two auxiliary methods of treatment on a large scale. The employment of the sulfonamide preparations and the liberal use of blood, or one of the blood-derivatives, have already proved of signal value in the treatment of the wounds of warfare. . . .

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Chest Wounds.—Summary.—Low incidence. High mortality.

Gunshot wounds of the chest account for a large number of fatalities, and it is probable that a large number do not reach the base hospitals. Operative interference for hemorrhage from the parietes or lung may have to be undertaken at once. Open pneumothorax is urgent and these sucking wounds must be stopped up by vaselined gauze dressings and strapped. Repeated aspiration is employed for hemothorax, and, if infected, closed drainage may be employed, if infection is not present. Pressure pneumothorax may be relieved by needling.

Chest Injuries.—All chest injuries, when possible, are treated at special "chest centers." In practice there are two types of cases: (1) "Hot case," seen immediately after injury. (2) "Cold case," seen several days later. For special details I am indebted to Mr. J. Holmes Sellors.

Shock.—For shock and loss of blood, plasma or blood are given in large quantities from the start, often up to five or six pints, aiming at maintaining the hemoglobin at 80 per cent.

Oxygen therapy is invaluable when given by B.L.B. mask, and the rate of flow should be not less than 4–6 litres per minute.

Sulfanilamides.—All cases are given an early course over the first two to three days, and if any sign of infection continues, a white count is obtained at the end of a week. The incidence of gas gangrene has been low.

FIG. 4.

FIG. 5.

FIG. 4.—Guillotine amputation stump after gas gangrene of leg. (Courtesy Surgeon Rear Admiral Cecil P. G. Wakeley.)

FIG. 5.—Guillotine amputation. Healing of flaps by adhesive plastic strapping. (Courtesy Surgeon Rear Admiral Cecil P. G. Wakeley.)

Local application into the wound seems good, but the results of injecting M. and B. into the pleural sac are as yet inconclusive.

Indications for Immediate Operation.—(1) Open pneumothorax with sucking wounds which lead to tension. (2) Active bleeding from an intercostal vessel (rare). (3) Pressure phenomena from internal valvular pneumothorax or accumulation of pleural blood. (4) Pericardial effusion of blood. (5) Retained foreign bodies.

Tension phenomena are recognized by the position of the trachea, and are relieved by needling. This is best done with an artificial pneumothorax machine to regulate pressure.

Sucking wounds should be closed without delay.

Foreign bodies are most dangerous in the region of the hilum of the lung and pericardium. Those larger than a bean should be removed, the hemothorax evacuated, and the lung tidied up. The results are satisfactory.

Rare Complications.—

Acute dilatation of the stomach.

Acute retention of urine.

Blast effects, when diffuse, recover quickly in four to seven days, and when there is much dyspnea and hemoptysis, general anesthesia is contraindicated, local and intravenous being the methods of choice.

Blast injuries may involve the abdominal viscera at the same time as the lung and the patients die from peritonitis two to three days later. In the section dealing with blast injuries, it will be seen that rigidity of the abdomen may be a common but spurious sign.

Hemothorax.—The blood, on the whole, remains fluid, and the treatment is aspiration and removal of the fluid as soon and as completely as possible. In early cases (24–28 hours) gas replacement is advised, and daily aspiration until the pleura is dry. If a mass of clot is left it would be well to remove it by a small local operation within 10 to 14 days. Breathing exercises follow this, as in all chest injuries, and are of the greatest value.

Infection.—In early cases of bomb injury this has been rare, but delayed cases of infection are treated as empyemata, by aspiration or rib resection. Although anaerobes are fairly often found in the pleura, with sulfonamides they have given relatively small evidence of toxemia.

Untreated hemothorax results in severe disability and patients seldom regain full respiratory efficiency.

Late Cases.—Cases received after 24 hours are treated expectantly and the hemothorax is dealt with.

Foreign bodies, if in a dangerous place or of any size and liable to give future trouble, should be removed about the third to fourth week, if there has been no evidence of infection. If the pleura is free, removal is done by open thoracotomy, and if adherent, by going straight through the chest wall and lung after accurate roentgen ray localization.

Fracture.—In fracture of the femur the Thomas splint has again confirmed its value as the best method for transportation, and may also be used

for fractures of the tibia and fibula. Traction is best maintained by a pin through the os calcis, but in forward areas adhesive plaster strapping extension, or a hitch over the boot and sock, may be used. For fracture of the arm, an axillary pad and bandage to the side and Gramer wire has been useful. Wounds complicated by fracture or involvement of joints are treated by ordinary methods, and plaster fixation under roentgen ray control with suitable pin-traction has greatly facilitated the treatment of these cases.

Fractured spines have been transported on stretchers in the prone position. With regard to the bladder, the general impression is that if there is any muscular power the de Pezza method is indicated, but if the paralysis is flaccid, tidal drainage through a retained catheter is better.

Burns.—At the beginning of the war, it was generally considered that the tannic acid method devised by Davidson, of Detroit, in 1925, had solved all our problems, and its very success led to the neglect of some of the pathologic problems of burns. War burns present special factors of their own, and the primary objects are to save life and limb and to preserve function. These and its special complications call for team work from different points of view. With regard to treatment, there is not yet any unanimity of opinion on the various methods being tested out. It has been found that for the commonest type of burn (the hands and face of airmen), tannic acid has not been satisfactory. It has led to scarring, and in the hand to gangrene of the fingers. It has therefore, been discarded in these conditions.

At the Naval Hospital at Haslar, under Rear Admiral Wakeley, the application of triple-dye, gentian violet 2 per cent, brilliant green 1 per cent, acriflavine 0.10 per cent, is recommended, and it is said to result in less scarring than tannic acid. On the other hand, Bunyan, at Oxford, is testing out the envelope method, by which the burn is segregated in a water-tight jacket, and irrigated with hypochlorite solutions (5 per cent Milton).

The Edinburgh school recommend the application of sulfonamide and glycerin.

From the point of view of skin grafting, Gillies considers that all these forms of treatment are satisfactory for burns of the first and second degree, but that burns of the third degree should be excised and not tanned, thus obtaining a granulating surface to which Thiersch grafts are applied as soon as possible. In this way, scarring and deformity is minimized.

First-aid treatment consists in getting the patient into an hospital as soon as possible. The burn should be cleaned under anesthesia (gas and oxygen or evipal or pentothal) with saline, dried with hot air, dusted with sulfanilamide and then sprayed with tannic acid and the part put at rest. For burns not involving the hands and face this gives satisfactory results. Sulfanilamide is considered unnecessary by the sponsors of the triple-dye method, which is also sprayed on. The tan falls off about the tenth day, and lanolin is rubbed in afterward.

Apart from the local treatment of the burn, it is the care of the compli-

cations which makes team work so desirable. With primary shock, the mortality is 2–3 per cent, whereas in secondary shock it is as much as 60 per cent. Primary shock is shown by low blood pressure, feeble pulse, and clammy skin. Warmth, oxygen, and fluids, and morphia for pain are given. Secondary shock comes on a few hours later. Unless there has been concomitant hemorrhage, blood transfusion is no good, owing to the concentration of the blood, and blood plasma is given to replace protein loss and to prevent edema. The danger from shock is between 24–48 hours, after that, from toxemia, which comes on several days later. This is usually due to streptococcal infection. Tanning has reduced its incidence, but when it is present it is necessary to remove the tan and give saline baths.

Chemotherapy in War Wounds.—Perhaps the most interesting feature of this war, and one in which it differs from its predecessors, is the use of sulphur compounds in the treatment of wounds. Although this subject is still in its experimental stages, there is a general consensus of opinion among surgeons that, where these drugs have been used, the wounds are less heavily infected than those of the last war, and that the wounded arrive at the base in better general condition and when enclosed in plaster they are, as well, comfortable. The sulfanilamide abscess, a new clinical entity, is a form of cold abscess, which may appear in those cases when their temperatures do not settle. Experimental work has been done with sulfanilamide, sulfapyridine, and sulfathiazole. Colebrook considers that the local treatment is superior to the oral route, and Fleming prefers sulfathiazole to the other two. Their effects have been most marked on the streptococcal infections, especially in clearing this form of infection in late wounds.

The anaerobe group of organisms are less susceptible to their action but of these *C. welchii* is more so than *Vibrion septique* or *C. oedematiens.* These three substances differ in their solubility; the first is absorbed in 24 hours, the second in seven to ten days, and the third in five to six days. Antitoxin sera also give protection against these infections, but at the moment there are no comparative results, or results from combined sulphur and toxin prophylaxis. Experiments have been conducted on mice by crushing muscle, introducing gas-forming organisms and sewing up the wounds. Those that had sulphur compounds introduced, survived, and those that did not, died. It is thought that these sulphur compounds act directly on the bacteria, arresting their metabolism. Their success in late wounds is probably due to the fact that bacteria lie in the fluid content or on the wound surface, and these come into intimate contact with the drug.

Zinc oxide paste, owing to the fact that it gives off oxygen, has been applied to wounds with gas gangrene infection.

Blast Injuries.—Blast has shown curious anomalies in its direction, distribution, and force, and this may be due to the fact that the casing breaks at its weakest point. The effects of blast have been studied by Zuckerman on animals (Fig. 6). It is due to the sudden conversion into gases of solid explosive material under great pressure. This creates a wave of high velocity

pressure which is followed by another of decreased pressure exerting a suction-like action. The high pressure wave falls to atmospheric pressure at a distance of about 30 feet, and its effects vary, as a general rule, with the distance from the blast: but, on the other hand, some people have suffered less ill effects near it than those further away. Usually, it gives rise to no surface injury, and is characterized by the appearance of blood-stained froth at the

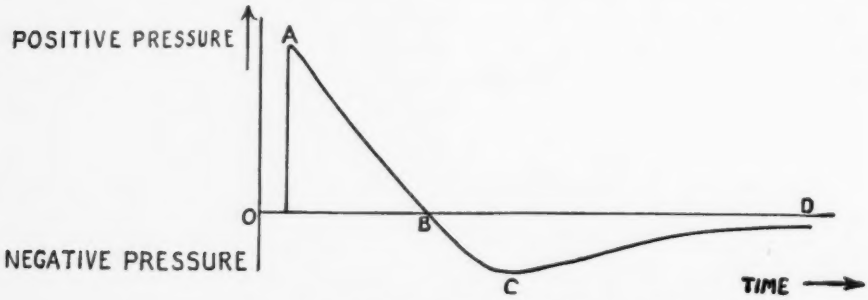

FIG. 6A.—Diagrammatic representation of shock-wave. Adapted from A.R.P. Handbook No. 5, "Structural Defence." Reproduced by permission of the Controller of H.M. Stationery Office

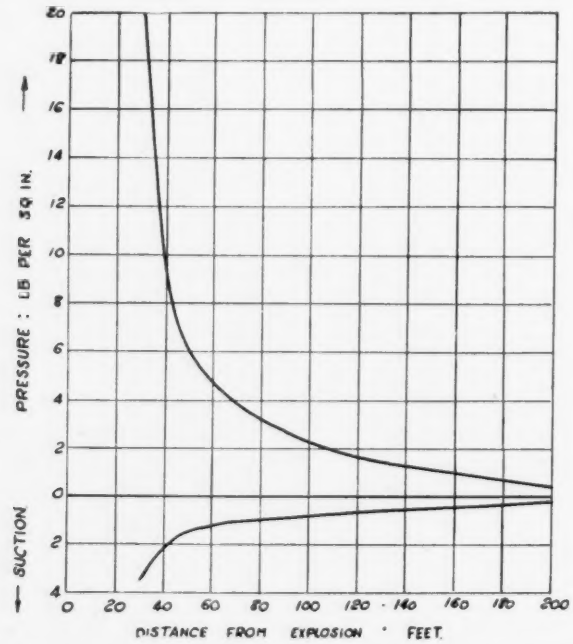

FIG. 6B.—Maximum blast pressures and suctions from medium-case bombs. From A.R.P. Handbook No. 5. Reproduced by permission of the Controller of H.M. Stationery Office. (Courtesy Proceedings of the Royal Society of Medicine.)

mouth. On examination of the chest the clinical signs resemble those of pneumonia (Fig. 7). At autopsy, hemorrhage of varying degree is found in the lungs (Fig. 8). Hemorrhages may also occur into other organs, such as the liver and spleen, intestine, adrenals, kidney, bladder and—sel-

dom—the brain. There is some evidence to suggest that the lung effect is due to sudden compression of the chest wall, and bleeding into the lung

FIG. 7.

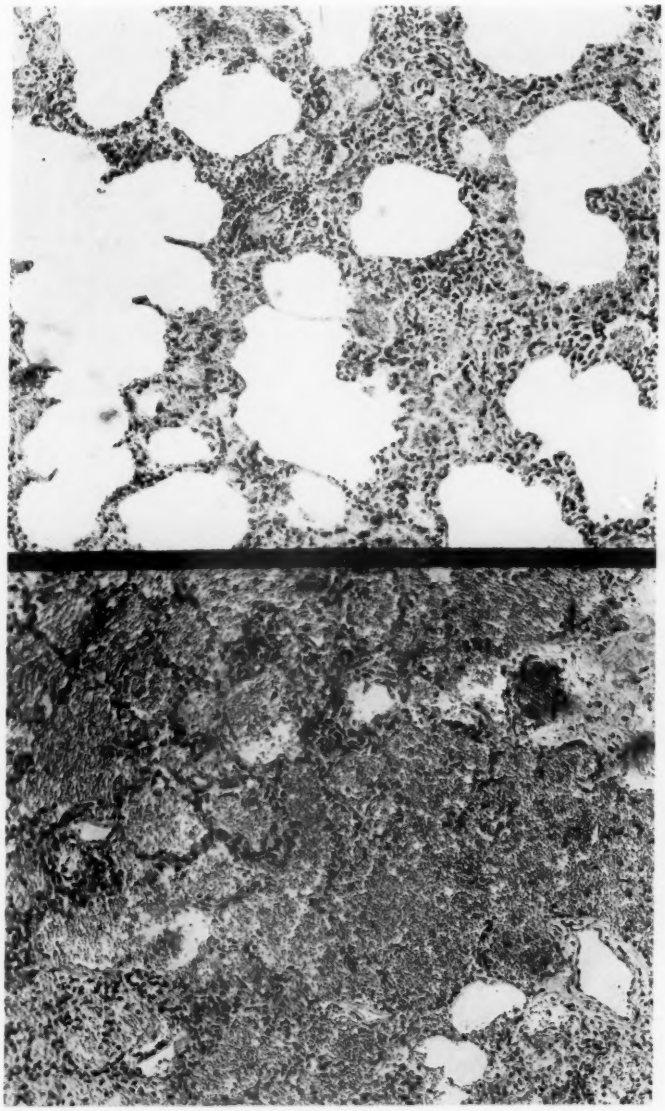

FIG. 8.

FIG. 7.—D. B., age 19. Blast injuries to lungs. September, 1940.
FIG. 8.—D. B., age 19. Blast injuries to lungs, delayed symptoms. September 17, 1940.

capillaries may go on for some days. The force of the blast may hurl people against objects and give rise to injuries from such a blow, and fat embolism has also been found in the lung. From the surgical aspect, this syndrome

is associated with rigidity in the abdomen, and this point needs emphasis to prevent unnecessary celiotomy and caution so as not to overlook coincident injury to the intestine.

Crush Injuries.—Different methods of warfare either bring new problems or revive old problems in new disguise, and the crush injury may fall into either category. It is characterized by acute renal failure occurring in

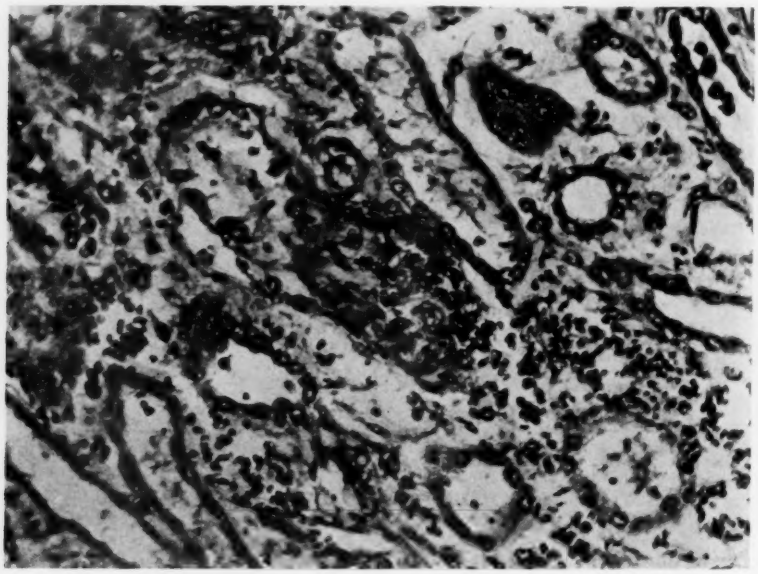

FIG. 9.—Photomicrograph of renal tubule from boundary zone, stained hematoxylin and eosin, showing necrosis of wall and commencing reactive changes. ×280. (Courtesy Proceedings of the Royal Society of Medicine.)

people who have been trapped under fallen masonry. The typical clinical picture is as follows. The patient has been buried for several hours and subjected to pressure. On admission, the general condition appears good; there may be no local injury, but when there is, local swelling, edema, whealing, followed by bullous eruption of the skin and local anesthetic areas, appear. A few hours later, in spite of vasoconstriction as shown by pallor, coldness, and sweating, the blood pressure falls and the hemoglobin concentration rises. Later, the urinary output progressively diminishes and contains albumen and many dark brown casts. The patient is alternatively drowsy and anxiously alert to the severity of his condition, and his blood pressure often remains raised. Edema, vomiting, and thirst then set in, the blood urea and potassium become increasingly high, and death in the bad cases generally occurs suddenly usually about the seventh day (Fig. 9). Autopsy shows necrosis of muscle and degenerative changes in the renal tubules. This micropathology resembles that found in cases of incompatible blood transfusion, but occurs without any transfusion (Fig. 10). It is not clear how much lowered blood volume and diminished renal blood flow or

katabolic products, produced by dead or dying tissues, have to do with it. There is some similarity in this condition to that of the toxemias of pregnancy and severe burns.

Treatment has been directed to increasing urinary outflow by heat to the loins and diuretics, and by increasing the blood volume by means of plasma transfusion. A crushed limb may show signs of incipient gangrene, and

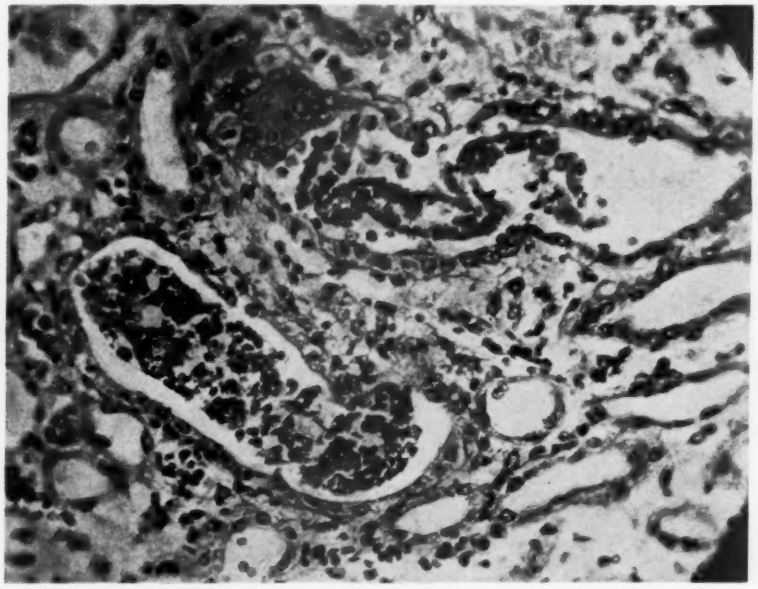

FIG. 10.—Photomicrograph of renal collecting tubules from medulla, stained hematoxylin and eosin, showing, above, ribbon-like pigmented cast, and, below, similar cast invaded by polymorphs and surrounded by disquamated epithelial cells. ×300. (Courtesy Proceedings of the Royal Society of Medicine.)

there is no evidence yet that early amputation has any beneficial effect upon the result. Treatment by means of cortin and decapsulation of the kidneys has been proposed.

Shock.—There has been almost a complete absence of shell shock in this war, but an increase of traumatic shock, and from what has already been said there is no doubt that the new experiences of this war will shed increasing light from different angles upon this complicated problem. The following short extract is based upon observations of my own colleagues at Charing Cross Hospital on air raid casualties, and it has been compiled by Doctor Blatchford.

This diagnosis of "shock" is based on ten out of 30 casualties which were transfused. The remaining 20 were eliminated because of coincident hemorrhage, toxemia, or their moribund condition.

(1) *Mental State.*—With two exceptions, who were excited, they were quiet and still. All had previously received morphia.

(2) *General Appearances.*—They were pale, thirsty and dry skinned,

with the exception of one who sweated profusely. Some had nausea and vomiting.

(3) *The Pulse.*—The pulse was never above 100. In one case, it was 60. Its quality varied, being either thin, impalpable, or collapsing.

(4) *Blood Pressure.*—This was below 100 in all cases. The pulse pressure was 20–30 and this and the pulse rate rose with the improvement of the patient.

FIG. 11.

FIG. 12.

FIG. 11.—Egg-bomb explosion injury to hand. (Courtesy Surgeon Rear Admiral Cecil P. G. Wakeley.)
FIG. 12.—Egg-bomb injury to hand (same case as Fig. 11), front view. (Courtesy Surgeon Rear Admiral Cecil P. G. Wakeley.)

(5) *Treatment.*—The need for transfusion was in proportion to the severity of the injuries, and with a blood pressure below 100. Plasma was given and whole blood if hemorrhage had occurred. A rise of ten points in blood pressure, improved color, temperature, and mental state were considered sufficient indications to take the patient to the theater for operation.

In severe shock, transfusion may be difficult on account of the collapsed condition of the veins, and it may be impossible to get the blood in without warming the limb.

Blood is collected in citrate under sterile conditions from grouped donors and kept in an ice chest. Such stored blood has been given up to six weeks without harm. Usually it is kept for 14 days and then removed for plasma separation. Dried serum has also been prepared from this, but has mostly been sent to the Near East.

With regard to results—the reaction rate, *e.g.*, rigors, is low. About one in 12 for blood and much less for plasma. In cases of hemorrhage, the results are good. In cases of shock without hemorrhage, the results are less dramatic.

There is a definite impression that lives are saved and much good done.

PHYSICIANS IN UNIFORM

DURING the last World War we had the opportunity of observing physicians in uniform. Just as a traffic cop is not at his best in his underclothes, so, we observed, many physicians did not respond well to the habiliments of militarism. Numbers of them, donning a uniform for the first time seemed to be under the impression that to be consistent they must cultivate a certain fierceness; others, apparently, considered that they must develop a heel-clicking smartness and a barking speech to round out their concept of official deportment.

Spurs and salutes did not contribute, frequently, to the maintenance of that imperturbability which Osler astutely advised medical men to cultivate, since the former frequently caused sudden shifts in the personal center of gravity at odd moments and the latter were executed in such manner and variety as the imagination of the officer dictated.

Then, too, subtle personality changes made their appearance. Quite decent, affable physicians developed "a cactus complex," a bristling, thorny untouchability usually accompanied by certain stigmas—small shoebrush mustaches, crop-like pendulous tumors dangling from the left wrist, and a dermatosis, resembling a small watch, usually on the left but sometimes on the right wrist hidden by the cuff. This was evidently an intermittent source of irritation, producing a sudden jerky forward movement of the left arm, a crooking of the elbow, and a nervous inspection of the area, doubtless to ascertain the rate of growth of the lesion.

—Editorial, N. Y. State Journal of Medicine.

SURGERY OF AIR RAID CASUALTIES *

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NO ONE could foretell the number of casualties likely to occur in London from a single raid nor the rate at which they would arrive at the hospitals, so that pre-blitzkrieg plans had to be modified as experience directed. In general, one found that one had overestimated both the numbers and the rate of arrival.

General Administration.—The personnel staffing a hospital reception center in which more than 50 casualties may be expected from a single raid should include two resident surgeons each with a skilled anesthetist and a house surgeon; a reception officer who is a physician of experience and whose duty it is to sort the cases in the reception center and afterward to instigate the treatment of all patients not requiring surgical attention, as for example those with concussion or "blast" injury; a physician who works with a junior pathologist and two students comprising a blood transfusion team, and a resident radiographer.

The postmortem attendant will need the assistance of two students in the mortuary during a heavy raid, and it is of importance to have an adequate staff of trained stretcher bearers sleeping on the premises ready for action. This job is very tiring and demands good physique.

The clerical side of the work entails the completion of many forms and the answering of inquiries. It is vital that this should be competently performed, since transfer to the base is necessary in 24 hours, if possible, in order to keep a sufficient number of beds empty. I believe it is always worth while doing the surgery even of minor wounds before their transfer, if it is possible; in very busy days, this cannot always be done, but the best surgical results are, however, obtained if the wounds are cleaned and sutured at the first hospital to which the patients are taken, and if the evacuation is undertaken with care to insure that each patient is sent to the appropriate special hospital (*i.e.*, head center, plastic unit, orthopedic team, *etc.*).

In addition to the officers already mentioned, a casualty officer working with a qualified assistant and two students in the first-aid post will treat all those patients whom the reception officer judges to be suitable for outpatient treatment.

There is never any urgency which demands a vast surgical staff during a raid, since on admission most of the cases either need some time for shock to pass off or have only trivial injuries. The blood transfusion team has much work to do before the surgical teams can start and the surgeon, at most, will need to apply a forceps or a tourniquet for the control of the hemorrhage. If visceral injuries require operation within the first few minutes of admission,

* Presented by title before the American Surgical Association, White Sulphur Springs, W. Va., April 28, 29, 30, 1941.

the case is usually hopeless as a result of blast and shock. The main surgical urgency is to start operating as soon at the patient's condition is satisfactory or else the morning is upon one with its routine hospital work to be done, or even the next raid.

Of the patients, no praise could be too high and one frequently notices a sense of elation in those with comparatively minor injuries on the realization of their escape. Hysteria is rare and it is only anxiety for a missing relative that disturbs their calm. Panic is no problem for it does not arise, but the same cannot be said of the rehabilitation of these people when they return from convalescence at a base hospital. They are suffering from the loss of the Englishman's "sense of property" and are reluctant to leave their own neighborhood. It is a gigantic task to fit them into place again and one which is being energetically tackled with great benefit not only to themselves but to their neighbors. Depression is justifiable after the loss of roof, clothes, and furniture, and can only be rectified by replacement. It is a real problem which the doctor meets in the outpatient clinics.

Shock and Hemorrhage.—Shock is often very severe and may bear little relation to the apparent severity of the injuries; particularly is this true in cases of "blast."

The unsuitability of intravenous saline in the presence of a capillary bed in which permeability is increased has been recognized for a long while and it is possible to kill a patient from water intoxication produced in this way; dextrose saline is little better.

Plasma, however, is ideal in such cases and is used in the form of citrated plasma; reconstituted serum-protein may also be used. Citrated plasma is easy to store in large quantities in vacoliter flasks and was introduced to augment the limited quantity of dried serum-protein which is difficult and expensive to produce and which is obviously more suitable for shipment overseas. Dried serum-protein is produced as a sterile brown powder and is used after the addition of sufficient distilled water to produce a concentration four times normal. It is difficult to work with since it is a sticky mixture and has to be given with a positive pressure. The quantity necessary rarely exceeds 200 cc. and its effects are dramatic.

Citrated plasma is equally efficient, producing great clinical improvement and rise in blood pressure in a few minutes. It has become the standard solution for intravenous therapy in severely shocked air raid victims since it is easier to use and cheaper to produce than dried serum-protein.

The value of a patient's hemoglobin rises in severe shock and this rise is proportional to the amount of fluid lost from the circulation. It was found that the amount of citrated plasma required could be estimated by use of the formula $HC/100 = 5/(5 - x)$ where x is plasma lost in liters.

Tabulation of the amount of plasma required for the treatment of patients with hemoglobin values varying between 105 per cent and 160 per cent will provide a ready reckoner for the transfusion officer to assist him in giving instructions to his team. The calculated amount of citrated plasma is run into

a vein after which a drip transfusion of one liter of whole blood is started and the patient taken to the operating theater. The whole blood is necessary since the figures arrived at from the formula supposed the hemoglobin to have been 100 per cent before the injury and because there was inevitably some small loss of plasma in the capillary bed when it began to run in.

Naturally, in cases of severe hemorrhage, whole blood is needed to replace the loss. A point of great practical importance is that all stored whole blood and all stored plasma must be filtered before administration. This is vital and death may result, if it is forgotten. Serum is not open to the same risk and the possibility of using stored serum, other than the reconstituted dried serum already mentioned, is being investigated. It has the additional merit that it can withstand some variations in temperature.

Surgical Technic.—Each surgeon must examine the patients who are under his care and give instructions for roentgenograms to be made to establish the diagnosis of fracture and to confirm the presence of bomb fragments. As far as is possible, this examination should not disturb the patient, and the removal of clothes in all serious cases is better undertaken in the anesthetic room after the patient has been anesthetized.

To insure smooth working, the surgeon must write down the names of the patients and the order in which they are to be sent to the theater. This list is given to the Ward-Sister, and copies handed by the house surgeon to the theater staff, and to the anesthetist, who can then arrange the appropriate premedication. This simple routine prevents both delay and exasperation.

All air raid casualties are covered with a fine brick dust which is ingrained in the skin, necessitating prolonged and gentle washing with soap and water after the anesthetic has been administered and before the surgeon dons his sterile gown. The time required for this is much greater than one would suppose, and must be followed by systematic firm scraping with a sterile curette to remove all particles imbedded in the epidermis. If this is not done, complete excision of all the skin affected is the only way in which the "grit-staining" can later be removed and this will necessitate extensive plastic operations.

Glass Cuts produce multiple lacerations of the exposed parts, affecting the face, neck, and forearms in the majority of cases. The number of lacerations is very great and the appearance suggests the passage of a rake across the tissues which hang in shreds. It must also be remembered that even a small triangular skin cut often conceals a slither of glass over an inch in length. Each wound must be explored with a forceps and the glass removed. Débridement of the edge of the wounds is quite unnecessary and usually impossible in view of the number of cuts and their close approximation. Excellent primary healing follows their immediate suture, and sepsis can be prevented by the liberal spraying of all the open wounds with sulfanilamide powder before closure.

Chemotherapy has been proven of inestimable value in air raid casualties both in preventing sepsis and in the sterilizing of old chronically infected

wounds. All raw surfaces are now automatically sprayed with it whether they are to be sutured or to be left open, and it is quite safe to produce a thin white covering, no matter how extensive the area injured. We have experienced no symptomatology which might be attributed to excessive dosage in spite of the fact that we must often have exceeded the suggested maximum dose of 15 Gm. The value of this treatment is perhaps the greatest lesson we have learned.

Compound Fractures are extremely common among these victims, and the principles governing their treatment may be summed up as conservatism in amputation, large incisions to remove lacerated muscles, sulfanilamide liberally sprayed, and rest to the limb in a plaster of paris encasement which is cut from end-to-end and "windowed" over the wound. The closed method of treating these cases has been extensively practiced in the past and has provided many dramatic successes, but I believe it is not the correct way in which to treat air raid victims in big cities. The limb needs constant careful watching and tragedy can so easily occur when the patient passes out of the care of one hospital and is transferred some distance into the country. New convoys arriving at the base inevitably take time to sort, and the damage may have been done before it is observed. The wound is dressed daily through the "window" in the encasement and is sprayed each time with sulfanilamide powder and covered with dry gauze. The gauze is soaked off daily with hydrogen peroxide in order to respray but the wound is otherwise kept dry. Sepsis clears up with remarkable rapidity and staphylococci and contaminants are removed by the addition of sulfathiazole powder to the sulfanilamide in the proportion of 1 :3. Later, a closed plaster encasement may be substituted.

Gas Gangrene has been encountered in ten wounds, seven of which were in the leg, two in the buttock and one in the brain. Of the cases in the leg, the calf was the most frequent site, and muscle laceration with small entrance wounds was the rule. There is a high rate of gas infection in those patients who have been buried under wreckage for many hours. None of these patients died and only one suffered an amputation. With the exception of the man whose leg was amputated, all were treated with the same technic.

Large incisions were made with no thought of cosmetic appearance, and all muscle was removed until normal bleeding was observed. A swab was then taken for laboratory purposes, and sulfanilamide sprayed throughout the length of the wound which was lightly packed with dry gauze. A "windowed" plaster encasement was applied and was cut from end-to-end. The cut was wedged open to prevent any obstruction of the circulation if swelling should occur, whilst, at the same time, the encasement served to put the limb at rest. Antigas gangrene serum (40 cc.) was given intramuscularly in the buttock and sulfanilamide gr. xxx daily by mouth. Each day the wound was inspected and resprayed and a swab taken for the laboratory. No gas organisms were recovered from any wound after 48 hours even in the case of the head wound which involved the frontal lobe.

A Complete Nerve Palsy often results from prolonged crushing of a

limb by heavy masonry although no fracture is present and there is no cut in the skin. I have seen the musculospiral nerve involved three times and the median nerve once. The paralysis is accompanied by the reaction of degeneration and remains complete for as much as six months, but all cases have ultimately shown signs of recovery without surgical intervention. The improvement is slow but steady, and all are now well on their way to complete restoration of function. Surgical intervention is not indicated in spite of the reaction of degeneration.

Foreign Bodies are often difficult to find and portable roentgen ray apparatus and a fluorescent screen are of the greatest assistance and save much time by being used in the theater to help the surgeon in his exploration. Many cases have 20 or more tiny metallic particles scattered in the soft tissues of a limb; these are quite harmless and their removal would be impossible, but large pieces buried in muscle tissue must be removed in order to minimize the risk of gas infection and to prevent prolonged suppuration. The removal of pieces situated near a joint is particularly important since they inevitably produce stiffness and limitation of movement if allowed to remain.

Antitetanic Serum is given to all air raid casualties on their arrival at the reception center and the dose officially recommended by the Ministry of Health is 3,000 units injected intramuscularly. I have seen no cases of tetanus develop in air raid casualties which have been treated in this way.

Burns of the hands and face are of common occurrence and much research has been done to determine the most satisfactory method of treatment. If the epidermis is only partially destroyed, tannic acid sprays or tannafax jelly is satisfactory, since the coagulum separates after healing in about two weeks, but where full thickness of skin has been lost, three months may elapse before it is shed. During this time, the small joints of the fingers and hand are firmly fixed, and the same applies to the eyelids, with the result that the freedom of movement is permanently lost. Moreover, the inevitable edema of the finger-tips in circumferential tanning may lead to necrosis of the terminal phalanges and pressure atrophy of the tendons over the knuckles.

To encourage movement from the start and to replace skin loss as soon as the recipient area is clean, are the objects to which treatment is directed. The method of choice is the daily immersion in warm saline baths, the concentration of which is slowly raised from 0.9 per cent to 1.3 per cent followed by the application of a dressing of vaseline-impregnated net (tulle gras) on which is sprayed sulfanilamide powder, and overlaid with gauze kept moist with hypertonic saline.

Healing is very rapid and can be followed by Thiersch grafting or Reverdin grafting as soon as the hemolytic streptococci have disappeared. This usually takes about ten days after starting sulfanilamide spraying. This treatment has the merits of speed of healing, and restoration of function, to which may be added the relief of pain to the patient, who looks forward eagerly to the saline bath each day, and who soon recovers his morale which is lost more readily in burns than in most of his misfortunes.

THE TREATMENT OF COMPOUND FRACTURES RESULTING FROM ENEMY ACTION*

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FROM THE FRACTURE SERVICE OF THE AMERICAN HOSPITAL IN BRITAIN, LTD.

THE experience gained in the Battle of Britain shows that airplanes and intensive bombardment from the air have introduced new problems in the medical preparations for defense that call for an entirely new organization. Formerly, it was possible to think of definite fronts, or zones of combat, behind which the Army Medical Corps set up its dressing stations and front line hospitals to treat and evacuate the wounded. Back of the zone of combat and far enough away to be relatively safe from air raids and fluctuations of the front were the base hospitals where the secondary treatment could be carried out and the wounded soldier brought finally to a stage of recovery when he could be sent home.

Now all this has changed. The front is a region instead of a line, or, as in England, it is represented by a coast closely guarded because of the constant danger of enemy invasion. But while below on the ground the opposing armies stand on guard protecting the frontiers, above in the air these are constantly being crossed by the bombing planes carrying destruction into the most remote points of the interior. Large cities and industrial centers are made the targets of hundreds of planes arriving in waves with scheduled regularity like trains at railroad stations, each unloading upon arrival its burden of high explosive and incendiary bombs. Facilities for the treatment of wounded must now be organized in depth as well as in width and no village or hamlet can be ignored in the provision of medical care for the possible victims of air raids. This is the background against which the treatment of compound fractures resulting from enemy action must be considered.

From the standpoint of medical organization there are, therefore, two parts to the problem, the military and the civilian. The military side, that is, the organization of medical care, splinting and transportation of the wounded from the battlefield under modern conditions of the war of movement is extraordinarily complex, but should be left to competent authorities of the Army Medical Corps who have studied the problem and made plans for dealing with it. For the treatment of the civilian air raid casualties, the experience in England points to the necessity of a separate medical organization of similar type to the Emergency Medical Service of the Ministry of Health. It is obviously impossible for the Medical Corps of the Army to provide medical units in each town or city to deal with such injuries when and

* Read before the American Surgical Association, White Sulphur Springs, W. Va., April 28, 29, 30, 1941.

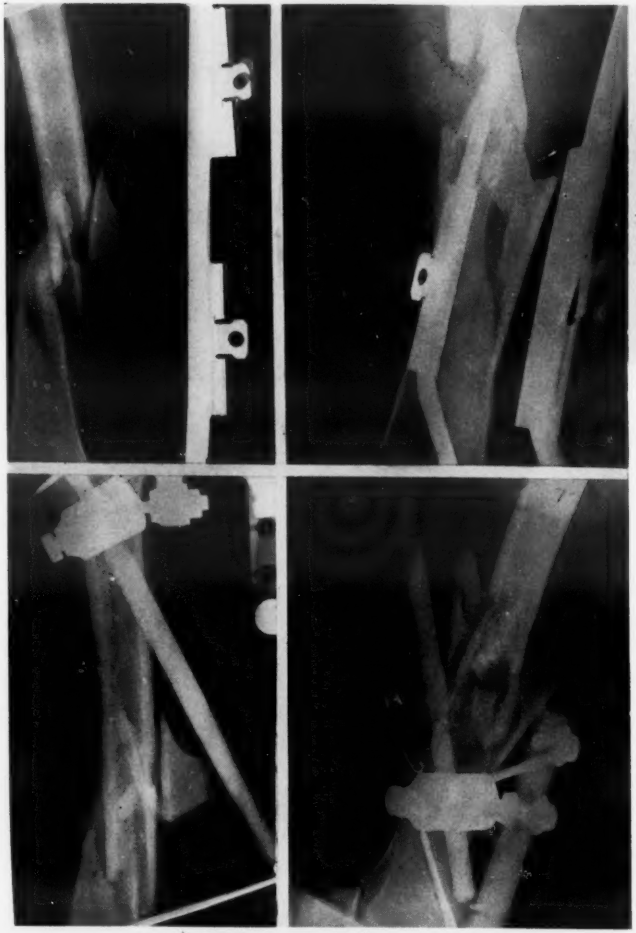
if air raids occur. On the other hand, all surgeons are not equally competent to deal with these cases, and it is important to have certain men designated for the job and to make use of civil hospitals and existing facilities when possible. Financial support for the care of the wounded must be supplied by the government and some form of regional supervision must be organized, with the right to shift personnel from post to post, to organize transportation, and to order the evacuation of the wounded to outlying hospitals when necessary.

The proportion of killed to wounded among the air raid victims in England is quite different from what it was on the battlefield of the last war. At that time, the figures showed about four wounded for every person killed. At present, the proportion is much more even, and there are approximately ten wounded for every seven killed. I do not know what percentage of air raid victims have compound fractures. Many of the wounded have comparatively minor injuries from flying glass and debris. All surgeons of experience agree in saying that the proportion of seriously wounded is small, probably not more than 15 to 20 per cent. Of the seriously wounded, probably 50 per cent or more would have fractures, not necessarily all compound, since as many may be injured by falling timbers and masonry as by a projectile. From this exceedingly rough estimate, it may be seen that the compound fractures do not represent as large a problem numerically as might be anticipated. I feel fairly sure that the figure would not exceed 5 to 8 per cent of the total casualties. Nevertheless, these cases are of the greatest importance because they will require the greatest care and will be the longest charge on the government.

This report on the treatment of compound fractures resulting from enemy action is based on the study of approximately 50 cases treated at the American Hospital in Britain during the period from October 1, 1940, to January 1, 1941. With the exception of a few cases left over from the evacuation of Dunkirk and who were wounded approximately June 1, 1940, all of these were air raid casualties. Since the hospital was situated in a relatively safe area which was rarely subjected to bombing, only a few fresh cases were seen, and the great majority received their primary treatment elsewhere and were admitted to our hospital at periods ranging from a few days to several weeks after injury.

Primary Treatment.—Comments on primary treatment are based on the inspection of these wounds and examination of the records accompanying the patients which showed what had been done, and also upon knowledge of the circumstances and conditions under which that treatment had been carried out. From this, certain observations may be made. First: The patients with compound fractures are apt to have multiple wounds and involvement of several bones. Second: Patients injured by high explosive bombs are easily shocked and do not tolerate extensive operation. Just what the shocking mechanism is, is not known, but there is a widespread feeling among the British surgeons that it is the result of some physiologic effect produced by the blast of the explosion. Cases have been reported of serious or fatal hemoptysis produced by blast and there have been other conditions as well

A



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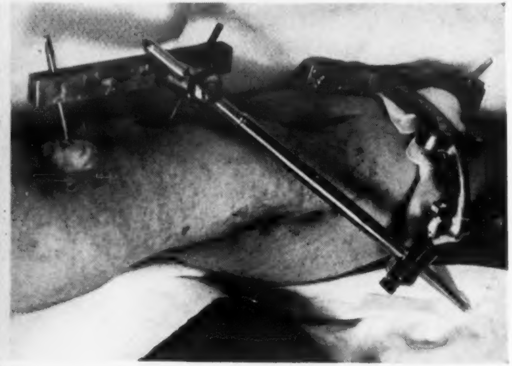

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Fig. 1.—A.F. Compound fracture of femur caused by bomb fragment. Wound débrided and then packed open. Evacuated to A.H.B. at end of three weeks, with leg in Thomas splint. Had large infected wounds on medial and lateral aspects of thigh. Fracture reduced by skeletal pins and reduction maintained by Anderson apparatus and plaster encasement from toes to groin. Orr treatment.

A. Appearance of fracture upon admission.

B. Appearance of fracture following reduction.

C. Appearance of limb three months after injury, wounds healed, callus formation well advanced.

including lesions of the central nervous system with paraplegia or palsy of fairly temporary nature.

The first step in the treatment of seriously wounded air raid victims is to get them to the hospital. Ambulances are constantly ready during air alerts and respond to calls quickly. Since the distances over which the patients are to be transported are short, little effort is made to splint fractured extremities at the places where the patients are found. They are gently lifted onto

A B

FIG. 2.—W.B. Compound fracture of humerus from gunshot wound with median and ulna nerve palsy. Treated by closed plaster technic and sulfathiazol. A. Original appearance of fracture upon admission. B. Appearance of fracture after eight months; wounds healed and fracture solid.

stretchers, loaded into the ambulances, and taken to the nearest hospitals as quickly as possible. It not infrequently happens that some of the wounded are buried under debris or pinned down by beams or girders and their rescue may take a matter of hours. When such patients can be reached but not released, doctors are called to administer sedatives. Upon arrival at the hospital the patients are examined by the Receiving Officer and the seriously wounded sent to the operating room, if their general condition permits. When the patient shows evidence of shock, he is given transfusions of blood or plasma, wrapped in warm blankets, given morphia and kept under observation until such time as his condition has improved so that operation may be done. Roentgen ray examinations are made routinely, prior to operative treatment. The nature of the operation is what is commonly referred to as a débridement —an effort to remove soiled, contaminated, and devitalized tissue with careful exploration of the depths of the wound, removal of all foreign bodies, and arrest of hemorrhage. I saw no case in which internal fixation had been employed primarily in these compound fractures. Powdered sulfanilamide was frequently applied in the wounds, but not routinely. Primary closure of the wound is still a matter of debate among English surgeons but, except in the case of small wounds that are seen within six hours of injury and can be cleanly excised, general opinion is opposed to it, particularly when it is likely that the patient will have to be evacuated to another hospital. Primary closure had been done in a few of the cases sent to us and suppuration occurred in one or two; the result would have been better if the wound had been left open. In the majority of cases, the wound was packed open with gauze, anti-

tetanic serum was administered routinely; antigasbacillus serum was used, but rarely.

The reduction of the fracture was accomplished generally by manual or skeletal traction and immobilization obtained by the application of plaster of paris encasements. In the case of fractures of the lower extremity, a Steinmann pin through the os calcis was frequently incorporated in the plaster and in some cases a second pin was inserted through the upper end of the tibia and incorporated in the plaster. This method of reduction and fixation was satisfactory in fractures of the bones of the lower leg, but was quite unsatisfactory in the case of the femur. About half of the fractures of the femur reaching us were immobilized in Thomas splints, either with adhesive skin traction or a pin through the os calcis. The fractures of the upper extremity were immobilized in plaster of paris.

The seriously wounded air raid victims in the large cities and industrial centers were generally evacuated to outlying hospitals of the Emergency Medical Service as soon as they could be transported with safety. This was done not only because it was desired to put the patient in greater security in a less exposed area, but also because it was necessary to keep large numbers of empty beds constantly ready in the hospitals in the vulnerable cities for such emergencies as might arise. In spite of this general policy, a great many patients were kept in the hospitals of London for long periods. During air alerts most of these were moved to the basement or in some instances they were placed on stretchers on the floor under their beds. They were always moved away from the windows, although the latter were covered by heavy blast curtains which reduced to some extent the danger of flying glass. Most of the London hospitals have received direct bomb hits, in some instances repeated on several occasions. Most of them are operating on a reduced scale of activity and in such cases the wounded who were brought in for primary treatment are evacuated quickly.

Secondary Treatment.—Secondary, or final treatment, is generally carried out in one of the outlying general hospitals of the Emergency Medical Service. London is divided into pie-shaped sectors with the apices meeting in the center of the city. In the point of each sector lies one of the large, teaching hospitals and medical schools. Each of these hospitals evacuates its patients peripherally and the other E.M.S. hospitals situated toward the base of the same sector are under its control. This is partly in order that all of the hospitals may be used in the education of medical students and the training of nurses, and also in order that continuity of treatment and follow-up treatment may be obtained.

The American Hospital in Britain operated a section of the Park Prewett Hospital, at Basingstoke, about 50 miles southeast of London. This was a general hospital with a large British staff, and it received patients both from London and from the south coast towns, particularly Portsmouth and Southampton. Our patients who were injured in air raids reached us anywhere from a few days to several weeks after injury. They generally arrived in large convoys of from 25 to 60 patients, and we would receive notification of

the expected time of arrival of the convoy some hours in advance. Such convoys might arrive by train, or by large motor buses, each carrying 12 lying cases on stretchers. Since all of these were old treated cases, no attempt was made to examine the wounds in the reception hut, and the patients simply were inspected by the Receiving Officer and distributed to the wards.

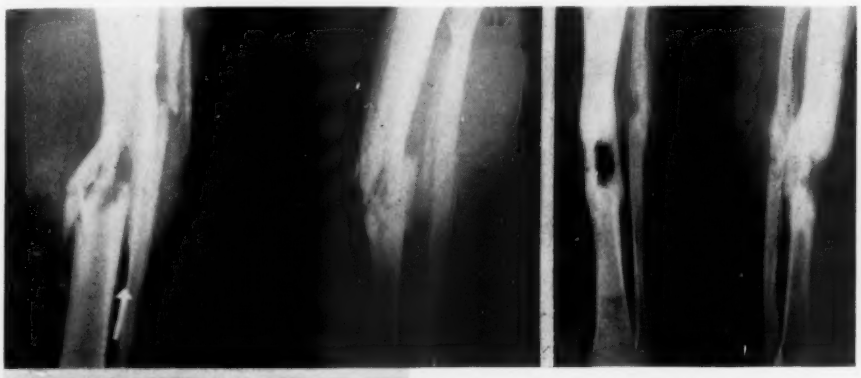
The notes of the surgeon who had previously treated the patient, together with the roentgenograms and the other clinical data, accompanied the patient. In many instances, these notes were very complete, and gave all the necessary information about the patient's original wound, what had been done at operation, and the treatment that had been carried out subsequent to operation. In other cases, where obviously the surgeons had been working under considerable pressure, the notes were deficient and in some instances it was not even stated whether or not antitetanic serum had been administered. There was nothing for us to do in such cases except to repeat the administration of the serum, although it had probably been given earlier. In some instances, there were preoperative roentgenograms, but no postreduction films. Since most of the extremities were encased in plaster, the notes were of the greatest importance in helping us decide what should be done in each case. Because the Orr-Trueta method of closed treatment of the wound was being used in most of these cases, we did not want to open the encasement and run the risk of changing the alignment of the fracture just for the sake of satisfying our curiosity about the condition of the wound. We made roentgenologic examinations in all of these patients and generally watched them for a day or two before deciding upon the necessity of intervention. When the patient became afebrile, the limb comfortable, the plaster in good condition, and the fracture well-aligned upon roentgenologic examination, we did nothing but observe and wait until there was some positive indication for intervention. In the majority of cases, however, it was found necessary to interfere either because of malalignment of the fracture or poor condition of the plaster, more rarely because of clinical symptoms demanding attention such as pain in the extremity, circulatory difficulty, fever, and other evidence of intoxication.

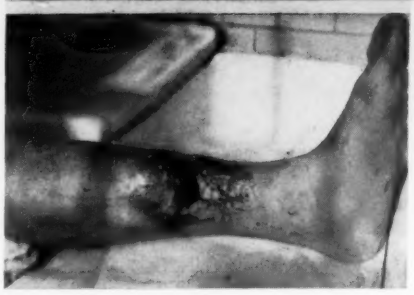
Under such circumstances, the patient was taken to the operating room and, under full anesthesia, the plaster was removed, and with rigorous aseptic technic the wound was dressed. The cavities were explored, pockets not draining satisfactorily were incised, and any remaining foreign bodies or entirely loose fragments of bone were removed. Cultures from the wound were routinely taken for bacteriologic study. Powdered sulfathiazole was generally introduced locally in doses varying from 3 to 7 Gm., the wound was then packed with vaselined gauze and covered with dry gauze, and a plaster casing reapplied.

The maintenance of alignment of the fracture during the dressing presented difficulties. In some cases, this could be done by manual support and when skeletal pins had been inserted in the os calcis or tibia, use could be made of these in conjunction with the traction arms of a fracture table to maintain the reduction. In other cases, however, when it was necessary to correct disalignment, or when there was extensive communication, we em-

ployed the Anderson or Haines systems of machine reduction with the aid of pins inserted in the upper and lower fragment as far away from the wound as possible. Since many of these cases were old and the malalignment fairly fixed by muscle contraction and scar tissue, only by the use of a powerful force mechanically applied and well-controlled, could we hope to obtain

A B





C

FIG. 3.—A.F. Compound fracture both bones of the leg caused by shell fragment. Treated by closed plaster technic with Kirschner wire through os calcis. A. Appearance of fracture upon admission. B. Appearance of fracture at end of eight months; solid union but still wearing brace. C. Appearance of wound at end of eight months. Superficial ulceration requiring skin graft.

improvement. Even with these methods, however, it was impossible to obtain, in many instances, the degree of improvement in alignment of the fracture that was desired. After the fracture had been reduced, a snug, unpadded plaster casing was applied, incorporating the pins. At subsequent dressings, the limb was placed in the reducing mechanism and the pins locked in it before the plaster was removed, so that rigid fixation was maintained.

These methods proved particularly valuable in the case of compound fractures of the femur where it was obviously impossible to maintain reduction by the use of plaster casings alone. In such cases, we used metal side-bars locked to the pins to preserve alignment and fixation, and then applied a plaster casing over all in order to have the advantage of closed plaster treatment of the wound. Since the position of the upper fragment was controlled by the pins, it was unnecessary to use a plaster spica and the hip could be left free. This made it possible for most of these patients to become ambulatory in a few weeks.

Under the Orr-Trueta method of treatment, the course of the patients under our care was extraordinarily good. Fever generally subsided in from

seven to ten days; thereafter the temperature remained at a normal level, toxic symptoms disappeared, and the appetite improved. Many of the patients who were emaciated upon arrival, began to gain weight. An impressive fracture was the comfort of the patients, in fact pain was quite exceptional and when present was always regarded as a sign that something was wrong, and if persistent that the wound should be investigated. The only discomfort was from the odor, but even this seemed to bother the doctors and nurses

FIG. 4.—F.F. Compound fracture of femur caused by bomb fragment. Fracture reduced by Anderson apparatus, wound treated by local application of sulfathiazol and closed plaster technic. A. Appearance of wound at end of five weeks after dressing and application of sulfathiazole. B. Same wound at end of nine weeks. C. Anderson apparatus in place at end of nine weeks. D. Short plaster encasement enclosing Anderson apparatus at end of nine weeks.

more than the patients. Deodorant bags made of fabric, impregnated with absorbent chemicals, were supplied to be worn over the plaster but many of the patients omitted to use them.

The plaster encasements were changed and the wounds dressed at as infrequent intervals as possible—usually from four to six weeks. The chief indications were softening of the plaster, oozing of pus from the ends of the encasement or atrophy of the extremity, so that it was feared that the immobilization might become less complete than desired. As healing progressed and less had to be done during the change of dressings, the use of an anesthetic was omitted. Immobilization was maintained until bony union was complete. I now have late reports on many of these cases showing that union was obtained in most in from four to six months. Many of the wounds have healed spontaneously and in others sequestration has occurred and, after surgical removal, healing is progressing. These reports also show that there has been no instance of serious infection about the pins in 28 cases in which the Anderson and Haines methods were employed.

The Orr-Trueta method of treatment has taken a firm hold in England and is being widely used. In my opinion, as well as that of many British

surgeons of much greater experience, it represents a great advance in the treatment of compound fractures resulting from enemy projectiles over the methods used in the last war. Having had experience with the treatment of similar cases, at that time by the Carrel-Dakin method, I can recall the vast labor required of doctors and nurses to carry out the meticulous technic of those daily dressings and also the pain and horror they caused the patients in spite of the greatest efforts at gentleness. I can contrast those recollections with a ward of 60 beds to-day at Park Prewett largely filled with compound fractures, where not more than one or two minor dressings are changed each day, and conclude that not only are the patients more comfortable, but the course of their recovery is more rapid and the results better not only in respect to alignment of their fractures and more rapid progress of union, but also in better control of infection and quicker healing of their wounds.

What is the secret of the success of the Orr-Trueta treatment? It can only lie in the thoroughness of applying that great surgical principle of rest, which is so frequently disregarded in other methods of wound treatment. Rest favors the walling-off of infection, and the local defensive and reparative forces. The smooth and uniform compression of the extremity by the plaster is also important in preventing the development of edema in the region of the wound and maintains a better circulation in the extremity. Finally, the sealing-off of the wound in plaster of paris and the infrequent dressings prevent or reduce the cross-contamination of wounds which recent bacteriologic studies show inevitably occurs when dressings are changed frequently, even with the observation of the most careful aseptic technic. Wound infections may be more difficult to control the more they are mixed with other strains of organisms. What effect chemotherapy, employed locally as well as generally, may have in these cases is difficult to determine, but, on the whole, the cases in which it was not used seemed to do about as well as those in which it was employed.

Dr. Calvin M. Smyth (Philadelphia, Pa.): When Doctor Pfeiffer and I presented this subject before the association, in 1935, the reception which it was accorded was something less than enthusiastic. On several occasions since then we have presented it elsewhere with very much the same type of reception. In other words, we succeeded in exciting little or no enthusiasm for the method. It is, therefore, a source of great satisfaction to us to-day to have heard what Doctor Broster had to say this morning and what Doctor Wilson has just said so well a few minutes ago.

In our paper, in 1935, we arrived at the same conclusions which we have heard to-day. We reported then our experience with the method we had started to use in about 1926, so we have now been using it for 14 years. While our total cases, of course, appear very small, when considered in the light of the mass experience of military surgery, we still have treated, now, 252 cases of major compound fractures of the long bones of the extremities by this method.

In this series of cases, we have had one instance of tetanus. We have had no occurrence of gas infection. The tetanus infection occurred in a child injured in a farm accident, although we got the case early, and it had prophylactic serum. With the exception of that case, we have had no anaerobic infection.

In these 252 cases, we have not had to remove the encasement in a single instance because of infection. On one or two occasions, I will admit, we lost a little sleep over not opening them, but the fact remains we have not done it.

We can sympathize with Doctor Gurd's position, when he rather questioned whether

the substitution of vaseline for liquid paraffin might be entitled to be called by a man's name. Of course, all of us who have used the methods for some time recognize Doctor Morison's and Doctor Gurd's pioneer work, and we sympathize and agree with their claim for priority. We cannot agree with Doctor Gurd exactly in his dehydration of the wound. We feel rather that it is best to encourage exudation in the wound and, therefore, we do not make any attempt to dehydrate.

Of course, all of these things are details. As Doctor Wilson said—and I was going to say it if he hadn't said it—"I dress him and God heals him." That still obtains. All of these methods are methods of dressing rather than of treatment, and nothing which attempts to substitute a method of dressing for good surgery can, of course, have no merit in itself.

Regarding chemotherapy, we cannot speak with any authority, except that it is interesting to note that all of these cases of ours were treated without benefit of any of the sulfonamide drugs used either locally or by mouth. When we began to use the method, these drugs were not available. Since they have become available we have not seen fit to use them because of our excellent results.

PREPAREDNESS REHEARSAL

CERTAINLY no one expected that the Lake Shore Limited would leave the rails at the "gulf curve" at Little Falls on that tragic night and inundate the local hospital to almost double its capacity with the torn and dying victims. Catastrophies are never expected. But this one found the hospital ready, for it was planned for catastrophe with rare foresight two years ago. The story of it was told on October 8 by Dr. H. D. Vickers in a paper read before the Herkimer County Medical Society. As reported in the local papers, he said in part:

"There are about 11,000 people in the city of Little Falls, and the Little Falls Hospital, an institution of 52 adult beds, nicely fulfills their medical needs. It is unusual that such a small hospital could adapt itself instantly to the demands of a major catastrophe. Normally operating on a 45-bed basis, the hospital admitted 83 injured persons in those early morning hours, and these were in addition to those who were already patients in the hospital.

"This preparedness was the result of thought and planning that took place about two years ago. When an addition was planned for the Little Falls Hospital, the possibility of a catastrophe happening in Little Falls was considered and provision was made for it.

"Does the average hospital staff know where to get large amounts of tetanus and gas gangrene antitoxin quickly for emergency use? Suppose a hospital used up its supplies of sterile goods, splints, plaster, roentgen ray films. How could they be obtained quickly? Are sufficient blood donors of known type available in the community ready for emergency use? What would it do if there were more patients than beds? Suppose the electric power were destroyed, what light would be arranged quickly?

"Indeed, what if the hospital itself were demolished? Where and how would medical and surgical care then be carried on? These are questions we can well afford to ask ourselves so that we will be better prepared. There are no universal answers to these questions. Each locality has its own medical setup, its own hospital, and its own community temperament. It has been said, 'It can't happen here,' but it can—in every single city, and sooner or later something will happen. It behooves the medical profession to be prepared."

—N. Y. Journal of Medicine.

THE EXPERIENCE OF THE CANADIAN ARMY AND PENSIONS BOARD WITH AMPUTATIONS OF THE LOWER EXTREMITY *

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TORONTO, CAN.

IT WOULD SEEM reasonable to suppose that with the enormous experience gained in the war of 1914 all the problems surrounding the amputations of the lower extremity and the equipment of the patients with artificial limbs would have been long since solved. I was amazed to find, however, that the conclusions published by the British Ministry of Pensions, in 1939, were in several important instances diametrically opposed to ours. Similarly, I find from conversation with Colonels Keller and Kirk that the American Army also has its own views. The time is ripe, therefore, for us to review what we have learned and to try to prepare ourselves to avoid a repetition of our mistakes.

To establish our right to opinions on this subject, it should be explained that since 1916 the Department of Pensions and National Health has operated in Toronto, an artificial limb factory in connection with the Pensions Military Hospital. Here, all the limbs for the pensioners are made and most of the surgical operations necessary to satisfactory fitting are done. From the beginning, this limb factory and the patients have been under the observation and medical direction of a succession of surgeons, chronologically consisting of myself, A. B. LeMesurier, D. E. Robertson and G. M. Dale. As the members of this group have been in contact with one another ever since the war, it has been possible to compare the experiences and impressions of each and to make general deductions that should come reasonably near the truth. A complete record of each patient since he became a casualty is available and will ultimately form the basis of an exhaustive report from Doctor Dale.

For the purposes of this symposium, I shall refer only to the four principal amputations, namely, the Syme's, the midcalf, the Gritti-Stokes, and the midthigh. Our experience with all other amputations has been unhappy.

Syme's operation has been the cause of more bitter controversy than all the others put together. In the first ten years after it was described, the abuse it received makes one wonder if jealousy of the preeminence of Scottish surgery may not have had something to do with it. All the arguments are well-known, such as the unsightliness of the stump, the great weight of the artificial limb, discomfort in the weight-bearing surface, and so on. Our experience with it, however, makes us think that a good Syme's is the best of all amputations and if I had the misfortune to have to lose a foot, I would prefer a Syme's operation to all others.

* Read before the American Surgical Association, White Sulphur Springs, W. Va., April 28, 29, 30, 1941.

The points in favor of this amputation are first, that in the bedroom and bathroom the patient can walk on the stump without taking the trouble to put on his artificial limb; and second, that when fitted with a good artificial limb he can walk or run and remain on his feet all day long. Twenty years ago I was put out of a squash tournament by a man with a Syme's amputation and the other day I met him on the street, still walking with practically no limp. He, in common with many others, never has a complaint.

That the ankle of the Syme's artificial limb is somewhat unsightly cannot be denied, but in the case of a man this is of no importance, as it is completely covered by his trousers. This objection is so important, however, in the case of women that for them the operation should probably never be recommended.

A review of the unsatisfactory Syme's amputations has shown that the chief defects have been first, improper relationship of the weight-bearing heel pad to the bones of the leg; second, looseness of this pad so that it wobbles about on the end of the stump when weight is applied; and third, pain resulting from irregular bony points, adherent scars, and neuromata.

One must admit at once that the Syme's operation must be done well or it will certainly fail. The flaps must be cut so that there is no redundancy of tissue and so that the flap which comes from the heel can be firmly stuck on the end of the severed tibia and fibula. The greatest care must be taken to see that this flap is not displaced during the application of the dressings or during the following two or three weeks, for if this accident happens it will ruin all possibility of fitting with a satisfactory leg. Long strips of adhesive plaster applied to the sides of the leg and over the end of the stump will guard against lateral or posterior displacement of the flap, and a light plaster bandage over all will give greater security.

This type of amputation has no place on battlefields or anywhere where there is the slightest risk of infection, or in limbs in which the circulation in the flaps is for any reason impaired. The failures that I have seen have all resulted from neglect to observe these rules. In the early years after the war, many bad Syme's were discovered and for a time the operation was under a cloud. During this period, a good many men had reamputations performed through the middle of the calf and so converting an end-bearing Syme's stump into a lateral-bearing one. It was several years before we realized that in doing this we had sacrificed stumps that were sometimes good for others that were almost always bad. It was then that we began refashioning defective Syme's stumps, getting rid of looseness in the flap, excising the painful adherent scars and neuromata and doing whatever else was necessary to make a more perfect stump. This is a procedure which we have come to value highly, as it is frequently successful and retains for the patient all the advantages of end-bearing.

One of the chief reasons that the Syme's operation is unpopular is that the artificial limb makers do not like it. I have discussed this attitude with many limb makers and concluded that it is due to three definite reasons.

First, the artificial limb fails to restore symmetry to the extremities. Second, many artificial limb makers cannot fit a Syme's stump or make a good leg. And finally, they think that not many surgeons know how to do the operation properly. While it must be confessed that there is something in each of these arguments, nevertheless, we are still of the opinion, based on our Army experience, that the Syme's amputation is the best of all amputations.

Of the amputations between the ankle and the knee, there is little to be said that is favorable. It is a sad fact that most of our soldiers who had this operation have had continual trouble. They have had repeated operations such as shortening of the stump, excising of scars and neuromata, removing part or the whole of the fibula and usually have ended up with an amputation above the knee. Ten years ago, the outpatient clinic at the limb factory was besieged by these young men complaining of all sorts of troubles, such as coldness and blueness of the stump, pain in the foot, ulceration in the scar, blisters on the weight-bearing areas, infection of hair follicles and so on. These stumps, except in rare instances, will not stand up under the strain of a day's work and even in those who lead sedentary lives are frequently the cause of a good deal of misery. The reason is that the patient's weight must be borne on the sides of the stump, on areas totally unaccustomed to weight-bearing. All sorts of devices have been tried, to overcome these difficulties but it is our experience that except in people who have a good deal of leisure, who can sit a major part of the day and are not called upon for much walking or standing, this operation is a failure. The important rules to be observed in the operation are that the stump should never be more than six inches long, otherwise it will swell and become blue and cold; it must have the fibula cut off short or removed altogether if the individual is of a bony type, otherwise there will be constant pressure trouble where the stump touches the socket; and finally, that the skin should fit the end of the stump, neither loosely nor tightly, lying on muscles that have retracted to or slightly above the level of the section of the bone. The old warning against a conical stump does not hold for modern artificial limbs, for a conical shape in these below-knee amputations gives the best chance of a good fitting.

With all these precautions, however, it has been our experience that these below-knee stumps are rarely satisfactory and are constantly the cause of loss of time from employment. After years of experimentation with various forms of reamputation, with remodeling of the bucket, and with fitting with the so-called slip sockets, it has become the standard practice of the Canadian Pensions Department to convert the troublesome below-knee amputations into the Gritti-Stokes type of end-bearing above knee limb. Once this has been done these patients cease to haunt the clinic and, except when repairs are required for the artificial limb, are rarely heard from.

Curiously enough, this has not been the experience of the British. In a publication on "Artificial Limbs" issued by the Minister of Pensions of Great Britain, in 1939, it is definitely stated that they rarely fit a man with an end-

bearing limb because, in their experience, such stumps have been painful. I am quite unable to offer any explanation for this. I wish to emphasize that, on the contrary, this has not been our experience and we are altogether of the opinion that if a workingman must have an amputation anywhere above the level of the Syme's, the Gritti-Stokes is the operation of choice. One naturally hesitates to sacrifice a perfectly good knee, but when a wealth of experience has shown that the below-knee stump is the cause of constant trouble and that this can be abolished by doing a Gritti-Stokes amputation and supplying an end-bearing limb, there is no room for further argument, at any rate, as far as Canadian soldiers are concerned.

Comparison of the Gritti-Stokes amputation with amputations in the mid-thigh is all in favor of the former. With an end-bearing stump, the man has a solid grip on the ground and walks much better. Taking his weight on the tough skin of the front of the knee, he is able to stand for long periods without difficulty. And being equipped with a stump socket of the corset variety, which does not reach the top of the thigh, he has much more freedom of hip movement than is the case in those who must carry this weight on the ischium.

As might be expected, not all Gritti-Stokes amputations are satisfactory. The most frequent cause of trouble has been that the patella is not properly placed on the end of the femur, or has failed to unite with it. This defect can be avoided by sawing through the femur just above the condyles and turning back the patella, from which the articular surface has been cut, like a trap door, and fastening it solidly in place with steel wire. In cases of painful stump due to such troubles with the patella, we do the operation over again and make sure of satisfactory fusion.

Occasionally, even the Gritti-Stokes stump will not tolerate constant hard standing. For such patients, some relief may be obtained by replacing the short thigh corset of the Gritti-Stokes limb with a wooden or metal bucket which allows the man to carry his weight on the ischium, or part time on ischium and part time on patella.

One sometimes hears bitter criticisms of surgeons in the clinic and in the limb factory because of the unsuitability of the stump to fit with the artificial limb. Such criticisms are not justifiable, however, when the amputation has been done in the presence of severe infection or spreading gangrene, as was the case so frequently after the battles of Flanders. In such patients, the guillotine amputation was a lifesaver only and was not intended to replace the formal amputation which must be done later.

What effect the use of the sulfonamide drugs and the Trueta plan of occlusive dressing will have on the need for amputation remains to be seen. Certainly the reports from Barcelona and now from England give ground for hopes that the prevalence of widespreading infections may be controlled and the necessity for amputations lessened.

A brief summary of the experience of the Canadian Army with amputations of the lower extremity is as follows:

(1) Syme's amputation when well done is the best of all amputations.

(2) Amputation through the calf, if well done, is suitable for men or women with a good deal of leisure and who are not called upon to stand for more than short periods.

(3) For men who are forced to earn their living on their feet, the Gritti-Stokes amputation is better than either the below-knee amputation or the amputation through the middle of the thigh. The stumps stood the test for 20 years.

(4) Any amputation, with the exception of the Syme's, is a very disabling condition and, in spite of the wonderful contribution made by the artificial limb maker, leaves a man very seriously handicapped. It is unreasonable to expect him to compete on even terms in the general labor market. This difficulty can be minimized by training the patients in some vocation in which loss of a leg is relatively unimportant.

(5) The conclusions herein enumerated are based on experience with 2,448 amputations of the lower extremity, of which 746 were in the leg, 142 at the ankle, and 1,468 above the knee.

DISCUSSION.—DR. A. B. LEMESURIER (Toronto, Can.): One of the most important things about a lower limb amputation stump is its ability to carry the body weight. This is best judged by how much pain or discomfort a man has when he is walking on an artificial leg, how long he can stand, or how far he can walk, or how often he is forced to take his leg off and go on crutches for days at a time.

It seems much sounder mechanically to take the weight on the broad horizontal end of an end-bearing stump than to take it on sloping surfaces, as is done with the lateral-bearing stump.

In Canada, the amputations of the last war have shown pretty definitely that a man with an end-bearing stump can stand the walking much better and has much less trouble than a man with the lateral-bearing stump. This is just as true now, when these men are getting older, as it was 15 years ago, which goes to show that the end-bearing stumps are not only comfortable and efficient, but they remain comfortable and efficient for a long time.

One reason for this, I think, is that with us, in the two or three years after the end of the last war, most of the bad end-bearing amputations were reamputated and only the good ones were left. To be at all satisfactory, an end-bearing amputation has to be good. The stump has to be well-fashioned at the time of the operation, and the wound has to heal without any infection. In a good many of the cases, the end-bearing amputations that are still being used as end-bearing amputations are now over 20 years old, and in the last 15 years there have been very few of these reamputated. As a matter of fact, the situation is now just the opposite, and most of the reamputations that have been done in the last 15 years have been done for the purpose of converting an unsatisfactory low knee lateral-bearing stump into an end-bearing Gritti-Stokes stump.

Now, the advantage of end-bearing over lateral-bearing is less noticeable above the knee than it is below the knee. Above the knee, a Gritti-Stokes amputation is better than a midthigh lateral-bearing amputation, but it is not very much better, because the ischial bearing of a midthigh amputation is fairly satisfactory. Below the knee, the Syme's amputation is infinitely better than a midthigh amputation. With a Syme's stump, the patient can walk about all day and seldom has any trouble at all. With a midleg amputation, the weight is carried on the sloping sides of the head of the tibia, and very often these surfaces are almost permanent, almost parallel, and it is a mystery to me how any weight is borne in comfort.

Occasionally, we see a tibia that is sloping considerably, but even with a well-shaped

head of the tibia, very few of these cases can walk well. Most of these do not do any walking unless they have to.

I think that the damning of the Syme's amputation by the British Ministry of Medicine and the recommending of the midleg amputation is all wrong. With us the Syme's amputation has been excellent and is still excellent, and I think it is about time that something was said in its favor.

There are very few cases in which the amputation can be done at the Syme's level, but in men of military age, with no gross vascular disease, if the amputation can be done at this level, I think it is undoubtedly the amputation of choice.

DR. LEO ELOESSER (San Francisco, Calif.): I do not wish to talk about the Syme's. I should like to say a few words about the below-the-knee amputations, to agree with Colonel Kirk. The main trouble with below-the-knee amputations, I think, is the wrangle with the leg maker. I can read between the lines of Colonel Gallie's remarks, that he has had perhaps the same difficulties we have had. The reason that the legs do not fit below-the-knee amputations is that the leg slides up and down, even in the socket. If you can get a leg to fit that does not slide up and down in the socket, you will avoid most of the trouble.

The principle brought out years ago by Donnelly, of putting two flat pads there to make the leg suspend from the condyle so the leg does not slip up and down will obviate most of these difficulties. The leg that was made under that model was very satisfactory, so much so that many of the soldiers, after receiving legs from the artificial leg manufacturers throughout the country, came back to have the original Leatherman leg fitted to them.

You can make many stumps end-bearing below the knee. The simple way is to have the man stand with his stump on an ordinary scale and see how much weight he can put on his stump without feeling pain. Then you have to do the same thing, leaning on the scale, and see how much weight he can bear on his knee. If you take the proportion between those two, you can get approximately the pounds of end-bearing he will bear on the end of the stump without trouble, and a great deal of the trouble below the knee, I think, will be obviated.

I think everybody agrees with Doctor Gallie that the end-bearing is far better than the side-bearing. If you can compromise between the two, as I have said, I think a number of these stumps will be satisfactory.

The Gritti-Stokes is not very popular, I think, in this country. In theory, of course, the Gritti-Stokes is wrong, because Gritti thought that the patella offered the end-bearing surface. Naturally, it does not. We do not kneel on our patellas. We cannot kneel on our patellas unless in kneeling we incline far forward and thrust our thighs far back. Ordinarily, when we kneel, we kneel on our femoral condyles. However, in practice, the Gritti, if it is properly done, is good, although it is a difficult operation to do successfully, as Doctor Gallie says.

The old Carden's, in which he makes the stump to consist of the femoral condyles very simply, I think has all the advantages of the Gritti without the complications and the knee exarticulation, although it has the same difficulty of unsightliness. The Syme's or end-bearing stump, I think, is superior to all the other stumps.

COLONEL N. T. KIRK (Medical Corps, United States Army): It was kind of Doctor Gallie to ask me to discuss his paper, because, you know, I do not agree with him on certain issues.

We were up in Canada, in 1931, at a meeting of the American Orthopedic Association, and we saw at least three dozen of these Syme's amputation cases there, fitted and walking. It was wonderful. Before that I had condemned it because I had not seen any good ones. I amputated through the leg.

I think the Canadian knows how to make a Syme's stump. I think most surgeons do not. It was modified by Pirogoff, because he could not cut the flap to make the Syme's, because he interfered with the circulation to the heel flap and, therefore, left in part of the tail and end of the os calcis to prevent that. That makes a very poor stump; it is too long; and you can not put a joint in.

The Syme's stump does everything Doctor Gallie says it does, when properly fitted. Our leg makers do not have the prosthesis to fit that the Canadians have developed.

If we had prosthetic makers here who made the same prosthesis for the Syme's and a man came in to me with a foot I could amputate at that level, I would do a Syme's. I have changed my mind about it.

There is no question about it that the end-bearing stump is the ideal stump, but we cannot always choose it.

I cannot agree that below-knee stumps, properly fashioned in the middle third of the leg, not longer than seven inches, or shorter than seven and a half, should be amputated and the Gritti-Stokes done. I cannot agree to that at all. Of course, I have not had the experience and numbers to back up the statement that he has. After the war, we will turn these cases over to the Veterans' Administration. In the last war, we fitted them, taught them how to use the prosthesis and got the shrinkage, then turned them over to the Veterans' Administration. A permanent-type prosthesis was furnished by the Veterans' Administration. Some are fitted well and some poorly, but I have been on duty at general hospitals since that time where we have treated from two to 500 Veterans' Administration cases and many of these amputations that have had trouble, and I have yet to amputate above the knee for a below-knee stump that is anywhere near satisfactory.

Those stumps can be repaired the same as Doctor Gallie repaired the Syme's stumps that were no good. If surgery is properly done on below-knee stumps and if the Canadian leg fitters are as good as our American leg fitters on fitting below-the-knee stumps, they are going to get along well.

I have a friend, a doctor, who was a classmate of mine—Doctor Estes and I were talking about it the other day—who before the war had a compound fracture of the leg, lost his leg, and was amputated through the leg. It is a poor stump, but he has walked on that leg ever since and is going about his business. He plays golf on that leg and dances very well. It is bad on his partner when the wooden foot gets on her foot because the foot does not feel the turn, and she has trouble getting out from under.

I have seen many of them. I had an amputation come back from France with a Syme's on one side and an amputation through the foot on the other. I did a bilateral amputation through the middle third of the leg. I heard two or three years later that that man walked down the hall and the students there could not tell what was the matter with him—that was the temporary prosthesis—he walked so well. He went up to New England and ran a milk route in New England. That is hard work in the winter time when the sun is not up. It is hard work on both feet. He did it with both legs up.

I cannot agree to cut off below-the-knee stumps for the Gritti-Stokes.

When these cases came back from France, unfortunately, most of them had amputations through the thigh to save life and infection, and most of the legs were guillotines through the legs.

Personally, I do not like the Gritti-Stokes. I like the plastic supracondyle. I cut the patella off and don't have any trouble about its uniting. They are end-bearing stumps. They will take end-bearing at the end of three weeks.

All these closed amputations are things done in the general hospitals and not under war conditions. When the amputation has to be done to save life or prevent infection following trauma, I believe there is only one kind to be done, and that is the guillotine at the lowest level, where we can save the patient's life, or through the fractured side, if it is due to end-fracture; and repair that leg later to give the patient the best stump we have that will prevent infection or that will save his life.

MINOR CAUSALGIA FOLLOWING INJURIES AND WOUNDS *

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MY EXCUSE for discussing causalgia is that though its major form, which is seen chiefly in war, is well-recognized, its minor form is looked upon by most surgeons as something freakish, hysterical, or perhaps an exhibition of malingering. Serious causalgias are apt to follow wounds of certain great nerves, incomplete divisions or bruises as a rule. The brachial plexus, the median and sciatic nerves are chiefly susceptible. The symptom-complex takes the form of a disabled extremity, reddened and glossy, edematous, cool rather than hot, subject to a peculiar burning pain, sore to the touch, intolerant of dryness, and intensely sensitive to drafts and jars. The bones are atrophied. The muscles are, or seem to be, partly paralyzed. Weir Mitchell, as you know, first described this disorder, attributing it mainly to wounds of the brachial plexus. During the last World War, Meige and Athanassio-Benisty called particular attention to its relation to wounds of the median and sciatic nerves. They put forward the very useful working hypothesis that these great nerves are susceptible because of their rich supply of blood vessels which, in turn, are abundantly furnished with vasomotor nerves. Apparently, it is through an irritation of these tiny nerves that the picturesque, secondary changes of causalgia arise, but that such nerves are strictly of a vasomotor nature is doubtful. They are more likely to be related to the sensitivity of the blood vessels, and to carry centrally-headed impulses which, as Moore has shown, enter the spinal cord by way of the posterior roots. One may, then, picture causalgia as a vicious reflex,† exciting, through local connections in the cord, a combined sensory-vasomotor dysfunction. Several diagrams of possible reflex pathways have been drawn (de Takats; Homans).

Related to the serious causalgias are traumatic edema and osteoporosis, Sudeck's atrophy of bone, reflex dystrophy of the extremities, chronic segmental arterial spasm, to mention several of the names which have been used. These differ from Weir Mitchell's symptom-complex in being excited not by trauma to the *large* nerves and vessels, but by a great variety of lesser injuries, blows, crushes, fractures, minor wounds, especially punctures such as are made by splinters, thorns, and bites of animals. It is of especial interest that they arise also from thrombophlebitis, that is, the inflammatory, obstructive form, doubtless because the nerves surrounding the great vessels are caught in the inflammation. The changes in minor causalgia include atrophy of bone, disorders of joints, edema, paresthesia and vasomotor dysfunction, which usu-

* Read before the American Surgical Association, White Sulphur Springs, W. Va., April 28, 29, 30, 1941.

† Possibly, even, an axon reflex taking place with the peripheral nerves and not entering the cord at all.

ally leave a cool, smooth, bluish skin, but occasionally vasodilatation. All these may appear together or in various combinations, a sensory-sympathetic disorder which may even spill over to the motor side.

Never think of these minor causalgias as being hysterical. Occasionally, one of them is overlaid by an hysterical glove anesthesia, perfectly plain to see, but usually the disorder has a recognizable anatomic distribution. Moreover, most of the victims wish to recover, wish to work, and take their plight hard. Often they are insurance problems and as such present the familiar difficulty that, having fallen back on outside help and suffering from a peculiar disability, which neither they nor others can easily understand, they are difficult to restore to a normal life. Yet, I have seen no one who, having been freed from pain and a disordered sense of touch, would not gladly try to use the affected limb. If such persons have any characteristics in common, it is the possession of cold, damp, cyanotic hands and feet, as exhibitions of an underlying sympathetic irritability of central origin.

The basic feature of all causalgias is pain. Indeed, the states which I am discussing have been very ably described by Livingston as "posttraumatic pain syndromes." But I do not propose to attack the problem of how pain is excited. That would lead me to discuss Sir Thomas Lewis' "nocifensor" nerves and Leriche's views on the relation of the sympathetic system to pain. Nevertheless, in spite of the former's accurate experiments, the most satisfactory working hypothesis is that of Leriche, namely, that whatever pain is, it is certainly influenced by the sympathetic system and can sometimes be abolished by cutting off sympathetic impulses from the affected part. There is even no certainty that the pain-exciting mechanism or the pain pathway is always exactly the same, especially since one case may be relieved by procainization or excision of Livingston's "trigger-point," another, by periarterial sympathectomy, and still another by one or more procaine blocks of the sympathetic supply to the limb. But, however difficult it is to account for the pathologic physiology of causalgic pain, it remains true that it depends upon a very unstable reflex, one which can often be broken up almost as easily as it has been established. Temporarily interrupt its pathway, on many occasions if necessary, and it may disappear forever.

A distinction should probably be made between those minor causalgias which result from wounds, especially those complicated by infection, and those which result from blows, crushes, and fractures. The two varieties have much in common but certain differences. The following are sufficiently representative of the two types:

ILLUSTRATIVE CASE REPORTS

Case 1.—E. J., a cleanly built woman, age 44, by occupation a worker in a lumber mill. A year and a half earlier, she had run a splinter into her left little finger. Sepsis followed, and eventually the little finger was amputated. The stump healed except for a small, discharging sinus, and pain soon became a serious feature. There were two types of pain: One, a throbbing pain in the region of the stump; the other, a vague pain radiating down the arm. There was present in that part of the hand supplied by the ulnar

nerve an acute sensitiveness to accidental contacts, and in the same area a bluish discoloration combined with a bad-smelling maceration of the skin. The whole palmar surface of the forearm and the median nerve area of the hand showed the characteristic dull sensitivity to pin-prick. A sinus, just distal to the hypothenar eminence and in the midst of the bluest area, remained following an exploration some months earlier in a search for a source of infection. The ulnar side of the hand required protection from all contacts. The patient was demoralized, irritable, almost uncontrollable. She slept only under opiates.

A sympathetic procaine block gave a typical vasodilatation for the hand, turned the purple area pink, and removed the paresthesia. Pain was diminished. Two days later a second block reinforced the effect of the first, demonstrating the temporary relief offered by sympathetic paralysis. But it was judged that a complete cure was unlikely to result unless by many repetitions of the block which, under the circumstances, was impracticable. Accordingly, a denervation of the ulnar artery was performed, a very simple procedure in which the veins, all nervous filaments, and all connections between ulnar nerve and artery were removed. The result was dramatic. Pain was completely relieved, and from that moment the skin of the ulnar field began gradually to take on a more normal appearance. The patient regained her poise and now, some six months later, though not in my opinion fully cured (a tiny sinus and a very local cyanosis about it remain), is confident of being able to resume her work.

An example of the second type is the following:

Case 2.—A. M., a stout girl, age 24, a candy maker. Some months earlier she had suffered a heavy pinch by a machine through the adductor muscle at the base of the right thumb. The skin was not broken. Immobilization, followed by various forms of physiotherapy, failed to halt the development of a typical posttraumatic minor causalgia. The girl repeatedly tried to work, but without success. Injection of procaine into the "trigger-area" (thenar eminence) gave fairly complete relief which only lasted overnight.

Upon examination, *both* hands were reddish and moist. The right forefinger and thumb were smoother than those of the left hand. Over an area confined to the thumb, its base and the radial side of the forefinger, pin-prick and scratch caused a dull discomfort. The back and ulnar side of the forefinger were not affected, nor was the finger-tip. Apparently, the disorder occupied the terminal distribution of the radial nerve. Any attempt to squeeze or even compress lightly the tissues at the base of the thumb was intensely resented. This sensitiveness prevented the patient from taking any sort of grip with the hand.

Procaine block of the sympathetic, made from above the first rib, produced an immediate and dramatic change and, of course, an Horner's syndrome. As the hand became hot and dry, the patient said: "I never felt anything like this before. It is different from what Doctor M. did" (injection of the "trigger-point"). She then gripped the hand as tightly as she pleased; deep pressure about the thumb excited no pain, and the paresthesia was found to have disappeared.

Relief lasted only 24 hours, but, from this time on, the symptoms never again were so severe. The effect of a second block lasted ten days; a third, one day; and a fourth, four days. In all, six injections were made, at the end of which time, except for some weakness of disuse, the patient considered herself well. Several months have since elapsed without recurrence, but even if the disorder returns, it should be curable by further sympathetic blocks. If not, sympathectomy will be required.

I can hardly make the matter more clear by describing in detail similar cases and their inevitable variations. A few are illustrated in the accompanying sketches: A broken wrist with minor causalgia in the area supplied by the median nerve; a wound by a splinter at the base of the thumb; a dog-bite of

the back of the hand; a human bite of the forefinger (a mother bitten by her own child); the tight application of adhesive plaster to the forearm because of tenosynovitis of the wrist—all producing the characteristic symptom-complex, namely, pain of an uncertain and varying character, a disagreeable feeling of numbness in the fingers, loss of the grip, very slight edema, paresthesia to pin-prick, atrophy of the skin and often of the bones, coolness and cyanosis of the part, and all in an area supplied by one or several great nerves, sometimes mainly in one nerve field but with a spill-over into others, very rarely, in the corresponding nerve field of the opposite limb. The presence of an especially sensitive "trigger-point" is not to be expected in all cases. The diagnosis is always clinched by the immediate relief secured by a sympathetic procaine block.

Minor causalgia following femoro-iliac thrombophlebitis appears to be a similar disorder.* Following the relief of edema and the attempted resumption of an active life, the patient experiences pain on standing as well as on exercise, a pain, as a rule, described as crampy or shooting, occasionally much like that of intermittent claudication. There is often some edema, less often cyanosis, but always dull paresthesia to pin-prick and intense pain when the calf is gripped or a tight cuff is applied. At the same time, the peripheral pulses are usually diminished and the arterial oscillations, both in calf and thigh, are often decreased.

Such a state seems to represent again a reflex disorder. It comes on gradually and, once established, tends to remain fixed though it may recede spontaneously. Leriche lays it to an inflammatory reaction about the great iliac and femoral vessels, a reaction which has involved the nerves supplying these great vessels. It is related, of course, to the gross arterial spasm which rarely appears at the onset of venous thrombosis and to the diffuse peripheral spasm which Leriche, and now Ochsner and DeBakey, have been able to relax by lumbar sympathetic block. Indeed, the evidence of an association of perivascular inflammation with both local and peripheral vasospasm particularly indicts the perivascular nerves of guilt for all these dramatic disorders, posttraumatic as well as postphlebitic, though it does not tell just how the guilty impulses travel. However, since both the vasomotor and sensory supply of the blood vessels appears to reach them at intervals, rather than pass along them continuously, a disorder which affects the whole limb is most likely to arise reflexly from initial impulses headed centrally. Apparently, Leriche's separation of vein from artery may be enough to break the postphlebitic vicious circle. Division of the vein may do it. But, above all, blocking the lumbar sympathetic gives relief, and as in the traumatic causalgias, repeated blocks cause progressive improvement—as a rule, a permanent cure.

Treatment.—Everyone dealing with these difficult cases develops his favorite technic for their relief. Livingston is very strong for the procainization or excision of the source of pain, the "trigger-point," be it a scar or a

* I have just seen a true posttraumatic minor causalgia of the leg which resembles, exactly, the painful postphlebitic state.

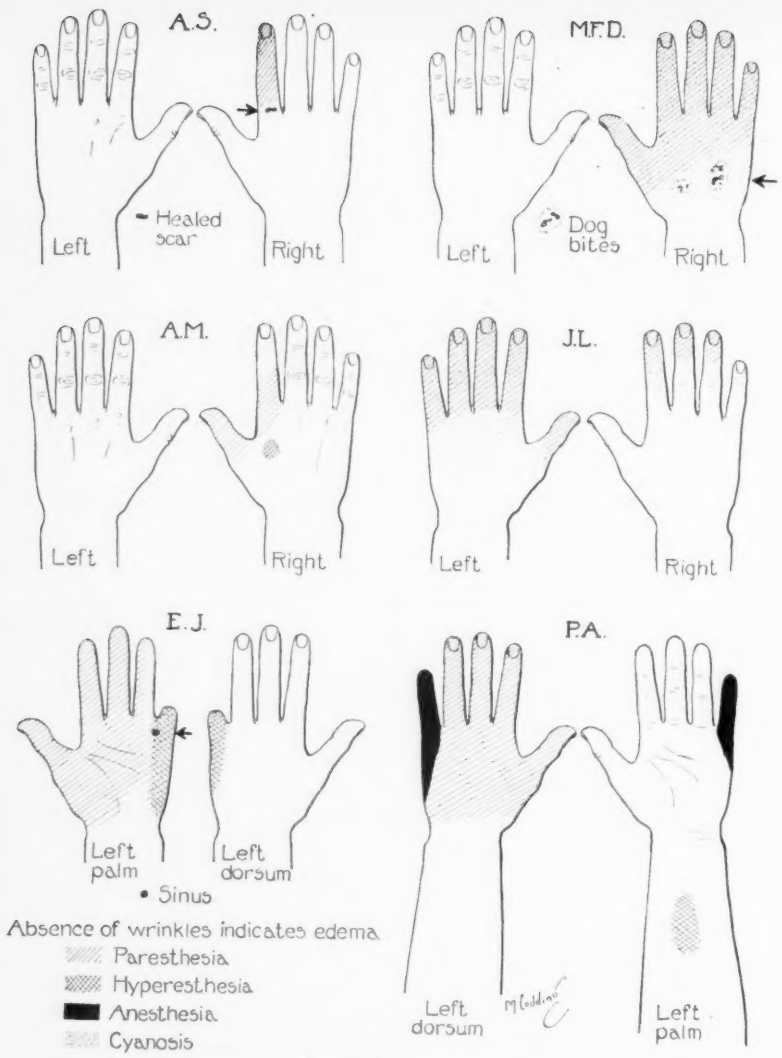

FIG. 1.

A. S.—A married woman, age 35, had been bitten by her own child at the base of the right forefinger two and a half months before coming under observation. Paresthesia and cyanosis of the right forefinger; slight edema of the whole hand. A novocain block relieved. Cure by intermittent venous hyperemia.

A. M.—An unmarried girl, age 20. A severe pinching bruise at the base of the right thumb. Paresthesia and cyanosis in the terminal radial nerve field; edema confined to this field. Relief by sympathetic block; cure by repeated sympathetic blocks.

E. J.—A married woman, age 44. A thorn wound of the left little finger resulting in sepsis and amputation. Paresthesia and edema of the whole left hand; cyanosis and hyperesthesia in the ulnar area of the left hand. Relief by sympathetic block. Very great relief, short of complete cure, by periarterial sympathectomy for the ulnar artery. Patient still under treatment.

M. F. D.—An unmarried woman, age 37. Dog bite of the right hand five months before coming under observation. Edema and paresthesia of the whole hand; cyanosis marked about the scars of the bites. Relief by sympathetic block and cure after one block.

J. L.—A man, age 46. Punctured wound by a splinter at the base of the left thumb. Paresthesia, cyanosis, and edema of the back of the left hand and fingers with a spill-over of paresthesia and slight edema to the middle finger of the right hand. Stiffness of the fingers and loss of grip. Relief by sympathetic block for the left side only. Permanent cure of the right hand by this block. Progressive improvement and, at present, recurrence following three temporarily successful sympathetic blocks. The patient is still under treatment.

P. A.—A man, age 23. Tight application of adhesive plaster following a sprain. Edema and paresthesia of the left hand; anesthesia of the little finger. Hyperesthesia in the area indicated on the palmar surface of the left forearm. Relief by one sympathetic block. Apparent cure by one sympathetic block.

local sensitive spot. Lehman cured a very advanced case by a periarterial sympathectomy. Smithwick tells me that he does not bother with half-way measures but performs a sympathectomy for the limb involved. I have even cured a mild case by repeated venous hyperemia. But my preference is for the sympathetic block, though I have employed periarterial sympathectomy with success and, in some instances, have had to come to lumbar or upper thoracic sympathectomy. A very satisfactory aspect of treatment is that you make no claim to the patient. There is little of the mental, or, if you like, hysterical element in most of these cases. You may tell the patient that you expect little from the procedure you employ; yet the result may be just as striking as if you had promised a cure.

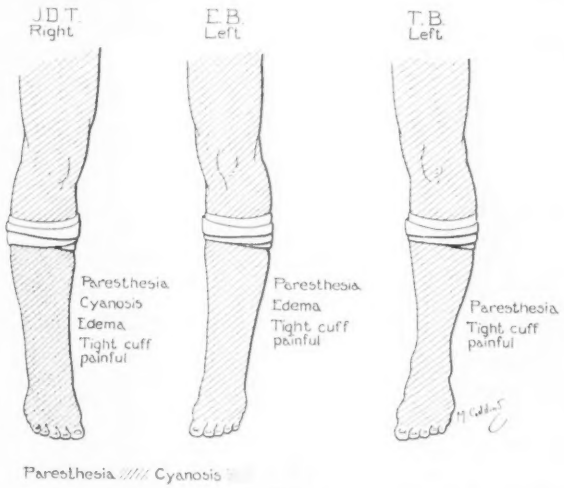

FIG. 2.

J. D. T.—A strong, heavy man, age 30. Deep, right thrombophlebitis following a hernia operation. Pain, cyanosis, edema, paresthesia, and hypersensitiveness to pressure of cuff. Temporary relief by lumbar sympathetic block. Patient lost sight of.

E. B.—A well-built man, age 57. Bilateral, deep, left thrombophlebitis without known cause. In the left leg, pain, edema, paresthesia, and hypersensitiveness to pressure of cuff. Relief by three lumbar sympathetic blocks. Recurrence of thrombosis with respiratory infection. Two more lumbar sympathetic blocks during acute stage. Rapid cure. Subsequently, no more pain. Lesser symptoms in right leg cured by treatment of left leg.

T. B.—A slender man, age 31. Deep, left, recurrent thrombophlebitis without known cause. Questionable involvement of right leg. Paresthesia and hypersensitiveness to pressure of cuff. Relief by lumbar sympathetic block and cure by three blocks at intervals of about a week. Lesser symptoms in right leg cured by treatment of left.

Sympathetic block by procaine is becoming a familiar procedure.* However, there are tricks to be learned, especially in the treatment of minor causalgia. A thermocouple, to inform the operator of the rapidity and completeness of sympathetic paralysis, is a useful aid. Make your block from

* Sympathetic block by procaine was introduced, for diagnostic purposes, by White, in 1930. Others had already injected alcohol about the upper thoracic sympathetic for angina pectoris.

above or below the first rib for the arm and at the first lumbar interspace for the leg. By the highest block for the arm, the pleura is relatively easy to avoid, and if the stellate ganglion is well swamped in procaine, a good effect is assured. The high lumbar block is far more effective than a low one, and one needle, only, is required. If the point enters the long triangular corridor in which the sympathetic lies, the procaine usually travels freely up and down. You may inject as much procaine as you would for any operation. I always use 30 cc. of a 1 per cent procaine solution for the arm and 50 to 60 cc. for the leg. With the last 20 cc., I combine pontocaine in a one-tenth of 1 per cent solution. Probably other longer-lasting anesthetics could be used, though I am afraid of alcohol.

Periarterial sympathectomy is, I believe, especially adapted to well-localized causalgias—a radial operation for the thumb, an ulnar operation for the ulnar field. Take all the tissues about the artery, including the veins, nerves, and outer arterial coat, looking especially for connections with the great companion nerve. If the operation breaks up the vicious circle at all, it may well produce a permanent cure.

Sympathectomy, that is, sympathetic ganglionectomy, or the preganglionic operation based on the studies of White and Smithwick, is the last resort. Those very familiar with it will have little patience with less radical procedures, but to anyone familiar with minor causalgia, there is a satisfaction in curing patients with the least possible expenditure of energy, which I beg to say is not laziness, but artistry.

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Discussion.—Dr. Edwin P. Lehman (University, Va.): When my former preceptor did me the honor of asking me to discuss his paper because nearly seven years ago I had reported a group of cases that fall into the category he has presented, I was more than a little embarrassed. Since that time I have learned, on my own initiative, nothing new about this challenging disease. I am delighted, therefore, that Doctor Homans is once more calling our attention to a subject with which all surgeons should be familiar.

In most of these cases there must be, of course, a pathologic process. It seems worth while, at the expense of presenting again material already published (Arch. Surg., 29, 1934, p. 92), to demonstrate the pathology of two cases. The first slide was obtained in the case of a typical and greatly disabling process in a young girl, resulting from a thorn puncture of the forearm and yielding promptly to brachial periarterial sympathectomy. This is the case mentioned by Doctor Homans. There is shown a marked inflammatory process centering about an arteriole.

The second slide is from an extremely early case, also of thorn puncture, occurring a month before treatment. In this instance, the removal of a small inflammatory nodule from the skin of the elbow resulted in prompt recovery, subjectively from a sense of weakness, clumsiness, and coolness of the forearm and hand, and objectively from coolness and pallor. Doctor Homans, I believe, doubts the status of this case as a true instance of minor causalgia. The definite manifestations of vasospasm and the slight otherwise unexplained disability, together with the prompt success of logical surgical treatment, led me to believe this to be an extremely early case before the onset of painful phenomena. The section shows actual invasion of the walls of an arteriole with inflammatory cells. As Doctor Homans has pointed out, a break in an abnormally functioning reflex must be effected for cure. In this last case it is believed that the actual point of origin (Livingston's "trigger-point") of the disturbed reflex was removed.

In connection with the study of sympathetic nervous system disorders, an interesting historic point may be made to which previous reference has not been found in recent literature, namely, that the first use of the thermocouple in studying clinically the temperature of the skin seems to have been made by Weir Mitchell, in connection with his study of these very conditions. In the classic monograph by Mitchell, Morehouse, and Keen, published in 1864, the following paragraphs appear under the chapter title: "Of the Condition of Calorification in Injuries of Nerves."

"A great deal of time was expended in futile attempts to measure the temperature

of the wounded limbs with thermometers. We failed, because it was impossible to overcome certain practical difficulties which we encountered in applying the bulb on flat surfaces; and because, in other cases, as in the hands, there was usually some loss of grasping power, so that there could be no just comparison with the sound hand, which readily embraced the bulb.

"We resorted at length to the thermo-electric disks of M. Becquerel, in connection with a very delicate galvanometer, kindly lent to us by Prof. Rand, of the Central High School, Philadelphia. The disks were applied on corresponding parts of the body, and the deflection of the needle of the galvanometer informed us which was the warmer of the two localities.

"The differences were so great, that the needle flew to the limit of its arc of motion in nearly every case; and thus it was that no numerical comparison could be made of the wounded and unwounded parts.

"The examinations were repeated, until we were satisfied of their accuracy, and beforehand each one of the two limbs to be compared was placed for half an hour in the same conditions as to covering or exposure."

Which of the three Becquerels is referred to is not clear. As a matter of fact, the discovery of thermo-electricity is ascribed to Seeback.

Dr. Herman E. Pearse, Jr. (Rochester, N. Y.): There are some inconsistencies in this condition that make it a fruitful one for further study, for phenomena are observed that do not correlate with our ordinary knowledge of the function of the sympathetic nervous system. I would like to record one instance that may illustrate what I am talking about.

One of our house staff sprained his ankle while playing squash. He continued with his game. A week later he began to have severe pain which was progressive, and went on to causalgia with osteosis. Local infiltration of novocain about the joint did not relieve him, and paravertebral block gave relief only for the duration of anesthesia. The same was true of spinal anesthesia. Because he obtained momentary relief with paravertebral block, a ganglionectomy was done. I believe the operation was thorough. There was no permanent relief. The individual continued with his symptoms. He had a periarterial sympathectomy on the femoral artery with cure. Why do you suppose that is? It doesn't make sense.

Dr. James C. White (Boston, Mass.): I have been interested in this problem since 1928, when it was my privilege to work in Doctor Leriche's clinic in Strasbourg, at a time when he was still treating some of the French wounded from the first war, who would have persistent pain for over ten years as a result of this type of injury. I have been on the lookout for these cases ever since in the general run of civilian practice at the Massachusetts General Hospital, and have been doing, as Doctor Homans said, diagnostic procaine block on the patients with unusual pain in the extremities, and out of quite a number there have been five very worthwhile results.

To summarize those very briefly: Two of them were crushing injuries to the index finger with trauma and continued pain up the arm in the precordium. Diagnostic procaine block gave relief for about two hours. If it had been longer, we would have returned to it, but as the novocain wore off ganglionectomy was done and the patient's pain was relieved.

There were two other patients with sprains and fractures. One had injury of the semilunar bone which finally was incised, with marked atrophy of the cortex, and decalcification, and had been given up by the orthopedic service. Diagnostic procaine injection relieved this case for six months, so he went back to work as an expressman, handling heavy trunks, and there was further relief by continued injection.

Another patient had a fracture with extreme decalcification of the wrist, great pain, and hyperplasia, with marked relief by procainization or complete relief as long as the procaine lasted, and then recurrence.

Another had Gritti-Stokes for thrombo-obliterans, with so much pain he was unable to use his artificial limb. By artificial blocking of the different nerves that went to the knee, he was given relief and he was able to wear his artificial limb for six months, and then had recurrence of pain, with further relief by procainization.

I hope you will continue to spread this gospel before the medical profession, that there is good reason to believe that if these types of pain which are accompanied by

vascular constriction in the extremities are treated by procaine block, or sympathectomy, a good many can be relieved by these relatively conservative methods.

DR. JOHN HOMANS (Boston, Mass., closing): Doctor White called attention to the period of relief. A very short period of relief generally indicates that repeated blocks won't do any good. I entirely agree with that.

There is another interesting matter, in case any of you try this treatment or see these cases. If you see an individual whom you treat and relieve, we will say, of a serious causalgia that prevents him from gripping his hand, and give him back usefulness of his limb, and let him go to work which traumatizes that limb, he will bring back his symptoms promptly, whereas, if you allow him to rest his limb, the symptoms may stay away for quite a long time. I do not know myself which is the right way to treat the disease, whether to let the individual use his hand and take a chance on his troubles coming back quickly, or whether to say, "Keep your hand out of trouble, and if you stay well for a few months you can consider yourself permanently cured." That seems to be a matter of trial and error.

The explanation of the phenomenon of cure by periarterial sympathectomy is possibly that, after all, you interrupt the central-going sensory pathway, and since the effect of the sympathectomy is indirect anyway, you are more likely perhaps, in some instances, to secure relief of these conditions by interrupting the impulses traveling centrally along the vessel.

I do not know that that is a very good explanation, but, inasmuch as a challenge has been given, there is no harm in trying.

PRESENT-DAY TREATMENT OF COMPOUND FRACTURES*

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SINCE THE WAR OF 1914–1918 four papers on compound fractures have been presented before the American Surgical Association: one in 1921, two in 1929, and one in 1935. Three of these were concerned with special features of the subject, while the fourth gave a more general approach, with evaluation of one type of treatment. In most of the current literature on compound fractures, one type of treatment is stressed to the exclusion of others. Many changes in therapy have occurred during the past 20 years, and the time seems opportune to state the basic principles in the care of these patients and to discuss in what way the various methods conform to them.

The basic principles in the management of a patient with a compound fracture are: (I) Treatment of shock and hemorrhage. (II) Prophylaxis and treatment of wound infection. (III) Accurate reduction and complete immobilization.

In actual practice these are associated together, at the same time, and disaster may be the result of neglect of any one of the three. Too often stress is placed by the surgeon on one chiefly.

I. *Treatment of Shock and Hemorrhage.*—This is the earliest problem. Nothing can be done for the soft parts or bone except in a live patient. Shock and hemorrhage are frequently grave and attention must be devoted to them first. Their treatment has been discussed so fully in the past few years that it is unnecessary to go into detail. We shall merely emphasize some points which concern compound fractures.

(1) *Drugs.*—Morphine is always indicated, except in head injuries. In the instance of multiple injuries, including the brain, it may still be administered if accompanied by caffeine. The Medical Department of the United States Army believes it has evidence that sodium amytal definitely delays the progress of shock.

(2) *Heat.*—Body temperature must be maintained in some way but, also, it must be done with judgment, not keeping a patient bathed in perspiration and losing body fluids. Blankets, hot water bags, and electric lamps beneath a cradle are all useful in the proper place. There is no excuse for ambulances not being heated.

(3) *Control of Bleeding.*—In most instances a pressure dressing is all that is necessary. The tourniquet has been grossly misused. An ineffective tourniquet has often caused serious loss of venous blood, which ceases as soon as the tourniquet is removed. Tourniquets should be of a type which can be

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loosened easily and definite orders should be issued as to the frequency of loosening. Usually, this should be done every half hour.

(4) *Traction.*—The major function of traction-fixation as a first aid measure before moving for transportation is to prevent or relieve shock and hemorrhage. Traction on a broken extremity relieves pain by putting muscles at rest and diminishes extravasation by causing relaxed fascia to again exert pressure on tissues within it. Traction also limits further injury from fragments churning about, thereby preventing increased shock and increased hemorrhage. Because an injured person has been transported without the benefit of traction is no excuse for lack of its application wherever it first becomes available. For instance, a person with a possible compound fracture arrives at an hospital in some sort of conveyance. If not in traction, this should be applied before he is even moved from the conveyance into the emergency room.

(5) *Fluid Replacement.*—This is extremely necessary at the earliest possible moment. Whether whole blood, plasma, serum or normal saline, *etc.*, is required has now been fairly well standardized by accurate laboratory tests. Desoxycorticosterone acetate seems to be a valuable adjunct. With all the interest shown in this subject under present war conditions, there is too little attention paid in most hospitals to the mechanics of arrangement for immediate action on arrival in the emergency room. Lives can be saved in civil accidents by attention to these details just as effectively as in war time. There were one-third more deaths from accidents in this country between September 1, and December 31, 1940 than from all the bombing raids in England during the same period.

Too often patients on admission to the emergency room are found to have no lowered systolic pressure, only to pass into profound shock a short time later. Lowered blood pressure is a late rather than early sign of shock. Mere notation of blood pressure, without adequate clinical evaluation or laboratory tests, may give a false sense of security. Shock is fairly characteristic of these injuries and preventive treatment, as well as early recognition of its presence, should always be considered.

(6) *Evaluation of the Patient.*—Multiple injuries are frequent. It is necessary to determine immediately, and without added trauma or exposure, whether injuries to the brain, spine, chest, abdominal viscera and kidneys are present, are a probable source of shock and hemorrhage, require postponement of further treatment of the compound fracture, or require first consideration when the patient's condition will allow of any further procedure. This is an assignment for the most experienced men on the staff, not the junior surgeon or resident.

II. *Prophylaxis and Treatment of Wound Infection.*—This should be commenced at the place of accident, and be continued concurrently with the treatment of shock and hemorrhage. To quote from Tinker,[1] in 1909: "The most important consideration in the management of compound fractures is still the wound of the soft parts. If our wound is aseptic, tetanus and blood

poisoning are impossible; bony union and a movable joint are favored; osteomyelitis will not develop; and a useful, if not perfectly normal, extremity will usually be saved." This is equally true a generation later, but too frequently disregarded.

(1) *Dressing.*—The wound should be covered, if possible, with a sterile dressing. Medical attention will rarely be available at the place of accident. Therefore, the use of antiseptics, irrigations, *etc.*, is not to be advised. Even the removal of penetrating foreign bodies is questionable, as they may have pierced a large vessel and be temporarily plugging it.

(2) *Traction.*—Traction-fixation before moving the injured from the site of accident is important in the prevention of infection. Whether compounded from within or without, the tissues are contaminated. Not to put the muscles at rest and to allow the fragments to move about increases the area of contamination. The origin of transportation in traction was in compound fractures in war. Yet many surgeons, who have admitted its great value in simple fractures, have objected to the use of traction-fixation in compound fractures. Apparently they are thinking of a bone projecting through a wound and covered with street dirt. They object to carrying this soiled bone back into the soft parts, as may happen under traction. However, this type of compound fracture is relatively rare. There are three types to be considered. The problem has been well expressed by Webb[2]:

Type 1.—"If the compound fracture is one in which there is merely a wound and there is no *known* dirty bone inside the wound, then the traction splint will not only protect the underlying tissues, but it will keep the bone from coming out through the opening and getting dirty or spreading dirt around inside if such exists.

Type 2.—If the compound fracture is one which has been produced by some sharp object penetrating the extremity, and if the sharp object was dirty and the wound is contaminated, the application of traction will keep from spreading the contaminating organisms around underneath the skin, and if we do not apply traction the contaminating organisms will be spread around.

Type 3.—If the compound fracture is produced by the end of the bone coming out through the skin and getting dirty, one now has a type of case in which there is a question and about which one can argue."

"From the standpoint of the greatest good to the greatest number, I believe that there is more harm done, actually, by the omission of traction splints in the first two cases than there is theoretically in the third group."

I agree entirely with this statement. In the First World War it is said that the mortality of compound fractures of the femur was reduced from 80 to 20 per cent by the introduction of the use of the Thomas splint, with traction. No one has a right to object to the application of fixed traction in the first two types mentioned.

The third type is not common and is an injury extremely serious both as to life and limb, under any circumstances. Most of these patients will be handled first by laymen. We must give them definite instructions and not

ask them to use their judgment. I believe, and many others agree with me, that the proper instruction to laymen in these cases is to apply fixed traction. In any application of traction for transportation, one should never attempt to reduce the fracture. A projecting fragment may slip back under the skin and a message should always accompany the injured stating that a fragment was seen outside the skin. If you, as a doctor, are first on the scene, you have a right to use your judgment in case of a bone projecting from the wound. If you believe you are able to transport the patient without danger of added trauma from the fragment of bone remaining inside the wound or added contamination of the soft parts, without the use of traction, you will properly use some other means. I do not know what it might be. Remember that these patients must be operated upon at the first possible moment anyway.

(3) *Débridement.*—(a) *Elapsed Time:* The length of time between the occurrence of the accident and the accomplishment of débridement is of almost equal importance with the method employed. Lives and limbs are lost from infection because this is not sufficiently appreciated. The wounds are contaminated at first, not infected. This contamination is in large part removable. The change from contamination to infection should be reckoned in minutes, not in hours. The aim should be to organize an hospital so that no time will be wasted in any department, thereby delaying the arrival of the injured in the operating room. This means the admitting office, emergency room, roentgen ray, laboratory, house staff and visiting staff. More than one motion should be going on at the same time. The necessary fluid can be delivered in a vein while a roentgenogram is being taken, or clothing removed—if everyone can be made to appreciate that in loss of minutes it may mean loss of life or limb. With laboratory control of the needs of the circulatory system, one does not need to wait, possibly beyond the optimum time before débridement, on account of shock, but can treat shock or hemorrhage and débride the wound all at the same time. We set an arbitrary limit of six hours from time of accident within which a débridement may be undertaken with expectation of success. But the danger of infection is greatly lessened if this can be made in one to two hours instead of six hours. In some instances when the injured has not reached us until between six and 12 hours, débridement may still be undertaken, although with much less hope of success, for contamination will usually no longer be limited to the surface. After 12 hours, débridement is contraindicated. Operative intervention then must be limited to enlarging the wound, laying open deep pockets, and removing gross foreign bodies. If infection is present, the attempt to excise these areas will only result in spreading it. Even though the patient is in good condition, every compound fracture of a major bone is a desperate emergency case.

(b) *Method:* On graduating from most medical schools, many students have little conception of débridement. In many hospitals, they gain no further knowledge of it. I have been told by house officers that débridement means cutting away one-eighth-inch margin of the skin. Under anesthesia, a large surrounding skin area should be shaved and surgically cleansed with careful

protection of the wound surface, in order to prevent its further contamination during this procedure. The exposed wound surface is cleansed in a similar manner before débridement is commenced. All irrigation is with a gentle, not a forceful, stream and from within outward rather than the reverse. Fresh instruments are to be used whenever dealing with possibly contaminated tissue, as distinct from foreign bodies or grossly contaminated tissue. Frequent change of instruments and contaminated drapes is important. As the word is used in this country, débridement means enlargement of the wound so that all tracts are laid open, knife excision of all devitalized tissue, removal of all foreign bodies, and hemostasis—the whole being accomplished under a constant irrigation with quarts of normal saline and with gentleness. One does not scrub muscles with a brush. Antiseptics are probably worse than useless. Nerves, tendons, and large blood vessels are to be preserved. Those portions of bone into which dirt has been ground are rongeured away. Bone fragments which have the slightest attachment to soft parts should be left in unless they are too badly contaminated. Smears of the worst contaminated areas should be made before excision for immediate examination for presence of gas bacilli. Aerobic and anaerobic cultures taken at this time may give a lead as to the type of drugs to be employed later.

(4) *Serums and Drugs.*—Unless the injured is known to be immunized by toxoid, tetanus antitoxin should be administered immediately in all cases where there is possible clothing or soil contamination. A second injection is to be considered if there is any further operative intervention after the first week.

I employ gas serum as a prophylactic and also use it in treatment doses on the slightest suspicion of gas. I cannot prove that it does the slightest good, but my impression of the material used for the past 15 years is that it is valuable from the clinical viewpoint.

I use the sulfa drugs locally in the wound. It is too early to state that the results are better with local application than with oral administration alone. But, with the tremendous concentration found in the local serum after local use, as compared with the blood concentration, and with no untoward local effects found so far, except increased capillary oozing and serum formation, I shall continue to use them locally at operation and follow up with oral administration. Meantime, until we have more proof, I shall continue prophylactic gas serum also.

I have had no experience in the use of roentgen ray therapy in the prevention or treatment of gas bacillus infection.

(5) *Closure of the Wound.*—The wound having been débrided within six hours, shall it be closed, drained or left open? Having just made every effort to remove all foreign bodies from the wound, I shall not now close the wound about a foreign body drain. I believe it is an irritant and more likely to cause than prevent infection. No débrided wound is free from bacteria. All we can hope for is that body resistance will cope with the remainder without a purulent process intervening. The best means to promote infection is to have ten-

sion in the wound as serum is thrown out. Therefore, as a general procedure, these wounds should not be sutured primarily, but left wide open.

Primary suture has been successful many times, but with its general use there are more instances of grave infection, osteomyelitis, amputation, and death. If these complications occur, even once in a hundred patients, this is sufficient contraindication to primary suture. By the time the fracture is healed, the wound will be healed, if no complications have arisen, so why gamble on the patient's life and limb with primary suture. Delayed primary suture is not objectionable, if the sutures are placed, but not tied, at the time of the débridement. The condition of the wound may warrant these sutures being tied at from two to five days. Secondary suture has no place in compound fractures. The danger of mobilizing infection makes this as hazardous a procedure as closing a primary case.

(6) *Drainage of the Wound.*—All pockets having been laid open, these should be kept open. If their sides are allowed to fall together, secretions may pocket-off, making ideal media for growth of bacteria. The original Dakin solution delivered in the wound by the Carrel technic is still the best method of antisepsis. However, the use of sulfa drugs, after adequate débridement, should make further antisepsis rarely necessary. Dakin solution is the best we have for liquefying necrotic tissue, which is present when infection becomes established. But the original solution is rarely used and the correct method still more seldom adhered to. Without both of these there is little advantage in trying it. Even in the War of 1914–1918, with all the effort made in proper training, the percentage of cases in which the Carrel technic was correctly applied was small. It does not detract from its great value when properly used to say it is time-consuming for doctors and nurses, painful for the patient in the daily dressings, and expensive in the amount of material used.

Vaseline, properly applied, with or without gauze, and with or without antiseptic, acts as an effective drain. It must reach every part of the depth of the wound, preventing dead spaces. The wound should not be dressed until it is made necessary by profuse discharge or objectionable odor. This saves energy and time of patient, doctor, and nurse, and greatly decreases the expense of dressing materials. With an adequate débridement, its simplicity makes its use preferable to the Carrel method in many institutions. With an inadequate or delayed débridement, the Carrel method is still preferable.

Elevation of the part in the early days prevents swelling and diminishes the amount of serum.

(7) *Immobilization.*—One speaks of immobilizing a fracture by external means, but one actually limits the activity of the muscles and prevents their action on the bones and joints. Complete immobilization is one of the most effective means of preventing and treating infection in compound fractures. If the muscles are put at rest, so is the bone, the fat, and the skin. Without complete immobilization, muscular action may change the site of contamination or infection at any moment. Russell traction, one-pin skeletal traction, or padded plaster encasement may immobilize the bone sufficiently so that union

takes place. None of these completely immobilizes the muscles. A non-padded plaster encasement, with or without internal fixation or two-pin traction, comes nearest to furnishing complete immobilization of the soft parts in order to prevent or allay infection. This does not include a window in the plaster at the site of the wound which immediately destroys the even pressure and allows edema, stasis of fluid, and increased danger of infection. It is natural to wish to inspect a wound, but the comfort of the patient, the fall of temperature, and the uniform progress of healing under skin-tight plaster is amazing.

(8) *Treatment of Established Infection.*—If emergency traction, débridement, serums and drugs, drainage of the wound, and immobilization have not been adequate or successful in our hands or someone else's and we are presented with an established infection, the principles are the same as in the care of any soft part infection in the early days of treatment and of osteomyelitis later, with this difference—in spite of treatment of the infection every effort must be made to preserve reduction and immobilization of the fracture. The two problems cannot be separated. Fracture healing will go on in the presence of infection but nonunion due to malposition in the presence of infection will rarely afford a useful limb by any method of treatment. Whatever else is done for gas bacillus infection, adequate surgical drainage remains the important factor.

(9) *Evaluation of the Wound.*—In the prophylaxis and treatment of wound infection, whether early or late, the virulence and extent of contamination and the severity of the soft part damage must be considered, as well as the elapsed time. More pathogenic organisms will be present in soiled clothing, cultivated fields, and highway dirt than in the wilderness, about the blast furnace, or in a clean home. More contamination will usually take place in a fracture compounded from the outside than from the inside, although both unquestionably demand débridement. Major blood vessel damage may be such that the part distal to it cannot survive. The muscle damage may be so extensive that it is evident immediately or at the time of débridement that a useful limb cannot possibly be obtained. With these factors in mind, primary amputation should sometimes be done to save life or prevent prolonged morbidity with a useless extremity as a final result. However, the sacrifice of limbs in civilian life does not need to be as frequent as it was a generation ago.

III. *Accurate Reduction and Complete Immobilization.*—Thus far we have considered saving the patient from death by shock and hemorrhage and from death or loss of limb by infection. It is necessary also to make his return to his usual position in society possible by obtaining proper union of the fracture. Although considered separately, the treatment of all three must interlock from the earliest moment.

(1) *Traction.*—Application of traction-fixation at the site of accident makes reduction simpler in the operating room. Traction should be continued under all circumstances until the patient is on the operating table, and in some form even there.

(2) *Roentgenologic Examination.*—Unless hemorrhage or the time factor makes this impossible, roentgenologic examination should be carried out before débridement. Although one may think the fracture will be entirely visualized at the operating table, one may be saved many surprises by insisting on roentgenologic examination before operation.

(3) *Reduction.*—In most instances, adequate débridement will result in visualization of the line of fracture. Perfect reduction can be obtained by sight rather than by palpation. Its accuracy is important both as regards infection and union. It should not be delayed until infection is controlled.

(4) *Maintenance of Reduction.*—This is of extreme importance. Having débrided the wound to prevent infection, complete immobilization is necessary if this is to be effective. If the fragments in an oblique fracture are slipping slightly each day, the likelihood of infection becoming established is increased. Having completed the initial treatment, further attempts at reduction, when found unsatisfactory, are liable to mobilize infection. Therefore, assurance of maintenance of reduction is necessary at the original operation.

Unquestionably, immediate rigid internal fixation of the fragments is the best answer. In spite of the tragic experience in its use during the earlier portion of the War of 1914–1918, means have been found since to make it safe. Either the Carrel technic or vaselined gauze, without any closure of the wound, can be used in the presence of plates and screws. Internal fixation must be rigid. The metal may be removed if infection sets in or when bony healing has progressed sufficiently. Although ideal, it is questionable whether this method should be used on compound fractures by surgeons who have not had experience in the rigid internal fixation of simple fractures.

Without this experience, or, in an instance in which for some reason plates, screws, *etc.*, seem contraindicated, the second choice is two-pin traction with one or more pin or wire proximal, and the other distal, to the fracture. Both are incorporated in the plaster of paris encasement, usually after machine reduction. Again, it is questionable whether this method should be used on compound fractures by surgeons not experienced in the use of the apparatus in simple fractures.

Third in order of effectiveness is the nonpadded encasement. It presents grave dangers and offers less security, but is probably safest of the three for the surgeon who treats only an occasional case.

Skeletal traction, with distal pin only, Russell traction in femur cases, adhesive plaster traction, padded plaster of paris encasement and splints of any material do not measure up to the present-day requirements for immobilization of compound fractures. However, conditions arise in which any of them may have to be the method of choice in the individual case. A molded plaster gutter aids immobilization of fragments in combination with traction and suspension. If there is a question of adequate circulation of the part, or of the thoroughness of the débridement, or of the virulence of the contaminant, closed plaster encasement should not be used for several days at least, but some form of

traction and suspension instead, allowing observation of the wound and surrounding tissues. These form a minority of the cases and are not frequent enough to warrant not gaining experience in the other methods.

With rigid internal fixation of the fragments, or with two-pin traction, the neighboring joints may be mobilized when it is believed that there is no longer danger of infection in the soft parts. Under all other circumstances, complete immobilization should be maintained until union is solid. Immobilizing devices must be changed if they become ineffective.

(5) *Evaluation of the Fracture.*—In some instances, it may be found that an extensive area of bone or even the entire knee joint or ankle joint has been completely blown away. Immediate amputation must be considered rather than accepting at best a prolonged convalescence resulting in an extremity probably useless even for a prosthesis.

Variants.—An attempt has been made to evaluate various forms of treatment in relation to the desired basic principles. The ideal should be aimed at and is often not as impossible to obtain as one thinks before it has been tried. The patient cannot be made to fit one's favorite method. However, many factors may make the ideal impossible in an individual patient, *e.g.*, condition of patient, elapsed time, experience of operator, facilities of hospital, and training of personnel. This is even more true of military than civil surgery. In war time, number of injured, distance transported before operative care, varying experience of medical officers, impossibility of keeping the wounded under observation at the same hospital, necessity of furnishing equipment for a certain routine, *etc.*, all complicate the problem. Conditions will rarely be such that internal fixation may properly be used in battle casualties. In spite of the excellent reports from the Spanish Revolution and more recently from Britain as regards the use of skin-tight plaster encasement as initial treatment, I still believe it should not be used until the patient reaches an institution where it is expected he will remain and where he can be closely observed. Traction-fixation splinting continued after débridement is preferable until the patient arrives at a more or less permanent base. Only by this means can the onset of gas gangrene and circulatory disturbance be satisfactorily gauged by the different observers through whose hands he will pass.

Under certain conditions, any of the methods mentioned above may be the best for that individual patient, taking all circumstances into consideration. We cannot dictate that one method shall be followed in all instances.

At present there is great need in our medical schools and hospitals for acquainting and intensively training the men in the principles and different methods of caring for compound fractures. In case of war, the younger men are the ones who will see the wounded in the critical six-hour period. There will be little opportunity for such training after induction. Unless it is given them now, while still civilians, we can expect again that most of the wounded with compound fractures, who live through the first six hours, will go on to chronic osteomyelitis or worse.

SUMMARY

In the management of compound fractures, shock and hemorrhage constitute the early problem, and infection the late problem. Accompanying each is the problem of the best method of dealing with the fracture. The basic principles, therefore, are:

(I) Treatment of shock and hemorrhage.

(II) Prophylaxis and treatment of wound infection.

(III) Accurate reduction and complete immobilization.

The comparative value of the various present-day methods of treatment in the light of these principles is discussed.

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[2] Webb, R. C.: Personal communication.

DISCUSSION.—DR. KELLOGG SPEED (Chicago, Ill.): The title of this symposium is Surgical Preparedness and the subitem of this paper is "Treatment of Compound Fractures." If this topic is further divided into civilian and military injuries, the latter implying wounds of warfare which are largely caused by explosives, we run into a cul-de-sac in one direction and a wide open field in the other.

Open fractures in civilian life have been with us for many years and are constantly increasing in number and severity. Their treatment should now be nearly a standardized one by proven practice and agreement among hospitals and surgeons, a *fait accompli*. Organized first-aid care, swift transportation and surgical care by the trained team are the keynotes of this.

The open fractures of war wounds have changed far more in the last two years than those of civilian life in the last 20 years, because modern totalitarian warfare includes a very high and possibly preponderating ratio of injuries to civilians rather than to trained troops in battle array. The cause of these injuries has been the high explosive bomb and, in very small proportion, the rifle bullet or slower velocity shrapnel fragments of the previous great war. We do not know consequently just what type of military open fractures we are going to encounter in any forthcoming war or where we are going to meet it either with soldiers or civilians.

Preparation for this surgical treatment must start in the medical school. It must be founded on the ideal treatment for all open wounds and the bone or fracture phase may be secondary, though most serious, involving as it does tissues easily infected and not easily nor quickly healed with all the latent complications of pathologic and mechanical nature. These points have been covered in Doctor Kennedy's paper. They include instruction for care of primary shock, thorough soap and water cleanliness followed by painstaking surgery, and finally splinting. Plaster of paris will probably never be used for primary splintage in our army or in a war of movement. It may be used in delayed care in remote bases and may be combined advantageously with skeletal imbedding under traction or support. For military preparedness, we shall have to have chemotherapy adjuncts even as we have antitetanic inoculation but should discard local use of strong antiseptics. Bacteriostatic action of the sulfonamides may become a military necessity but we are still short of the *sterilizans magna* to cover all contingencies.

It is my humble opinion that this Association should lend support to the teaching of the most up-to-date methods of treatment for open fracture to all practitioners and should attempt to force all medical schools to pay more attention to undergraduate teaching of this subject. In particular, I would like to stress the necessity for mass preparation of a few types of proven standard splints for use on upper and lower extremities. Large reserve supplies of these splints should be on hand, not only in all types of military outfits but also in civilian centers, manufacturing plants, mines, and all large cities possibly subject to destructive totalitarian warfare. The standardization specifica-

tions and expense of manufacture of really useful splints could be simplified and unified and costs could be greatly reduced by national action.

DR. WILLIAM DARRACH (New York, N. Y.): I have rarely heard a paper with which I disagreed so little as with Doctor Kennedy's paper. It is quite disappointing.

I do want to emphasize one or two points: First, the importance of the three major indications and careful first-aid treatment, whereby additional damage is prevented or limited. Second, the time at which débridement is carried out; the time at which the operative treatment of the fracture is carried out, because the operative treatment of the fracture not only includes thorough excision and removal of all dead tissues with free exposure of all involved parts, but also the accurate reduction of the fracture.

We are driving a team of horses that are not used to working together. We are struggling against the change from contaminated wounds to infected wounds, and against the displacement of broken fragments of bone. That is where the double team comes in, and the treatment of one often interferes with the treatment of the other. We have got to bring them together into a smooth-working team.

As to the time at which débridement is done: we have seen quite a little change, even in our own bailiwick, in our results dating from the time when we began to treat shock in the operating room. We used to wait until they were over what we call their primary shock, and then take them to the operating room, hit them again, and then treat the secondary shock. Now if, when a patient arrives in the accident ward, any pulse can be felt or any blood pressure registered he goes to the operating room, only stopping off at the roentgen ray department, and there the shock treatment is begun at the same time we begin our preparation for operation, the two going hand in hand. In the large majority of cases, the patient comes off the operating table in better condition than when we started. That is due largely to the efficacy of our shock team, which works with us.

We have to remember that our only real time to get a leg straight or an arm of proper length is at the time we get our first operative opportunity. After that it is too late. The accurate reduction at the time of débridement is of great importance.

As to the immobilization: the immobilization cannot be too rigid. Doctor Kennedy brought out that any movement of the fragments afterward simply reopens our deeper part of the wound and starts the infection spreading over again, and this happens each time. Personally, we prefer rigid internal fixation. It is doubtful if that can be carried out in war casualties under many conditions, but it might be done. The nearest approach to that rigid internal fixation is the ideal method, whichever method the individual can best use.

I agree with Doctor Kennedy on wound closure, and I want to emphasize the point that no matter how high the percentage of primary closures people are getting away with, it is unnecessary and an unwise risk, because the one case in 50 or 25 or 100 of primary closure that goes bad is so very bad that you will wish you had not done it. It results not only in spreading infection but in sepsis, amputation, and sometimes death. This can be avoided, if you do not add insult to injury by adding tension to your spreading infection.

DR. J. DEWEY BISGARD (Omaha, Nebr.): I happen to have some experimental data which I felt were sufficiently pertinent to bring into this discussion.

In evaluation of the method of treatment of fresh traumatic wounds, two questions must be answered. First, does the method of treatment render the wound free of bacteria? I think no method does. Second, if it does not render the wound free of bacteria, does it inflict injury to the soft tissues and thereby interfere with the normal processes of defense against the bacteria?

In this series of rabbits, incisions were made along the abdomen under sterile conditions, and various substances you see here were placed in these incisions; in another group, solution was injected under the skin with a fine needle, this area cut out at different intervals and sectioned to determine the degree of inflammatory reaction produced.

If you will notice, there is no inflammatory reaction here and very little in the first three. There is practically none from ether, but very considerable inflammatory reaction from the other solution. These are the three most commonly used in this country; the most severe inflammatory reaction comes from green soap. In the last three, there were gross abscesses.

In another group, compound fractures were produced and the radii removed in those animals; they were infected with *Streptococcus hemolyticus, Staphylococcus albans,* and the first one, the control, was merely closed. It suppurated with necrosis of the bone, but finally there was some union. After the rest of these were contaminated, and in this one green soap was placed in the wound, there was suppuration and failure of union. With alcohol there was some union. This caused as much disturbance of the osteogenic properties as did these others. This was washed with salt solution, and there was no suppuration.

This merely shows saw cuts through the radius with the wound closed. Here sulfanilamide was placed around the fracture and the wound closed. It shows there has been no change in the rate or the completeness of the repair of the fracture as a result of sulfanilamide as compared with the control.

DR. FRANK L. MELENEY (New York, N. Y.): When I saw Doctor Kennedy's title on the program, I asked him if he would send me a carbon copy of the paper. I thought I might like to discuss it but when I read it I found so little to disagree with that I decided not to discuss it at all.

However, in the corridor, someone came up to me who is well-known in fracture circles, who has treated a great many fractures and has written a good many papers on the subject, and said: "You take your bacteriology pretty seriously, don't you?" This fellow is noted for his wit. I thought he was kidding me at first, but a little later I went back to ask him if he really meant what he said. He said: "Yes, bacteriology is of no importance." So I decided to discuss Doctor Kennedy's paper on that basis.

About the only part of his paper on which I would feel any qualification to speak is the prevention of infection. I believe what this Fellow had in mind was this: That now, in the present state of our knowledge, we have new substances in the sulfanilamide group which are able to control all infection. This would indicate that the last word in the treatment of infection has been said. I want to remind the Fellows that the same thing was said when antitoxin was discovered. It was thought that if an antitoxin could be found for one organism it could be found for all organisms, but that was to have very serious limitations. The same thing was true of vaccines. When Pasteur found vaccines for certain diseases, it was thought that any disease could be treated and controlled by vaccine. I predict we will find that the sulfanilamide groups also have their limitations.

Recognizing the value of these new drugs in hemolytic Streptococcus, pneumococcus and gonococcus infections, and the importance, therefore, in the control of wound infection, we find that there is some limitation to their value in staphylococcic infections, and particularly in anaerobic infections.

The literature that has come from England and from this country about the clinical use of these drugs, as well as all the experimental work, gives very contradictory evidence with regard to the importance and value of these drugs in the anaerobic infections. The very fact that the wounds come back with foul odor, indicates that the anaerobic organisms are active, even in those which have had sulfanilamide, either local or general.

For that reason, I consider that the bacteriology of these compound fractures is of great importance. I believe that in our civilian cases, at least (it may not be possible and probably will not be possible in the stress of war), we ought to know the bacteriology of these wounds. Of course, "Where ignorance is bliss, 'tis folly to be wise" is a motto which some would like to hold, but I do not believe that it applies to this situation. I think we ought to know. A surgeon ought to know whether there are organisms in that wound which are likely to give rise to infection of a certain type, particularly the organisms of gas gangrene and tetanus. We ought not to sleep at night, if we know those organisms are there, until we are sure that they are not going to manifest themselves in the wound.

I believe that all of these cases should have a complete bacteriologic analysis for that reason, and that that should be done with all the débrided tissue.

That leads me to speak of one other point, and that is the method of débridement. I believe that if débridement is done first, with careful removal of the foreign bodies and the gross tissue, with one set of instruments, there will be less distribution of those organisms in the wound, and if, at the very start, the wound is irrigated with an irrigating can.

I believe all of that material should be taken and sent to the bacteriologic laboratory

in the shortest possible time and a complete bacteriologic analysis should be given to the surgeon. After this is done with one set of instruments, then the rest of the débridement may be done with continuous irrigation and plenty of it, but I believe that, always after the débridement is complete, the wound should be filled with saline and fluid taken for bacteriologic analysis, because that will indicate what organisms have been left in the wound after débridement and clearing have been done.

Dr. J. Albert Key (St. Louis, Mo.): I was kidding Doctor Meleney a little when I was talking about bacteriology. We do not have the bacteriologic facilities out West that they have in the Presbyterian Hospital in the city of New York. Consequently, we use sulfanilamide and sulfapyridine.

I do want to differ with all the men who spoke on the point of primary suture. It is too bad when one of them goes bad, but I think if the surgeon who sutures the wound is on the alert and watches the wound, he can open it up in time to save it. You can shake your heads all you please, but that is true.

No one has mentioned the fact that leaving these bones exposed in the bottom of the wound courts subsequent infection, subsequent nonunion, and subsequent loss of bone tissue which might have been saved.

I think we should pay more attention to the fact that the new sulfanilamide drugs are dissolved in fluids independently; that is, with a saturated solution of sulfanilamide you can saturate that solution with sulfathiazole, and you can also add sulfadiozene. I haven't used sulfadiozene, because I haven't had any, but I am combining the first two and putting them in wounds. The sulfanilamide is absorbed first, and there is some sulfathiazole left. I think by the use of those drugs you can at least double the time in which the primary suture is safe. The primary suture may never be safe in the hands of a man who is not a surgeon. A man who is a surgeon, and who understands handling traumatized tissue, and knows what is going to happen afterward, can suture most compound fractures, I should say, within 8 to 12 hours and do it safely; and can cover the bone and have it heal as though it were a simple fracture. I think that is a great deal better than leaving it open and letting it heal by granulation. I do not believe the secondary suture has very much place in the treatment of compound fractures.

I believe that more surgeons should be trained to evaluate the seriousness of a wound, to evaluate the result of their own débridement and know what they have accomplished when they get through; then most of them will know what they can suture and what they have to leave open, and leave those open only when they have to do so.

Dr. Robert H. Kennedy (New York, N. Y., closing): I wish to thank Doctor Key particularly, with whose theories I disagree absolutely. In discussing this problem, I cannot help thinking of the presentation of the late Doctor Connors some years ago, in which he compared groups of compound fractures which were closed by primary suture and a group in which they were left open. The number of infections at that time was slightly greater in the group which were left open. There were no amputations and no deaths. There were slightly fewer infections in the group which were closed by primary suture, but there were several amputations and several deaths. That is enough to answer the problem for me.

THE USE OF ADRENAL CORTICAL EXTRACT IN THE TREATMENT OF TRAUMATIC SHOCK OF BURNS *

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A RECENT SURVEY of the mortality due to severe burns in a group of 190 cases at the Pennsylvania and Graduate Hospitals during the past decade shows that a majority of the fatalities occurred early, within the first three days, and apparently were the result of secondary shock (Fig. 1). Current reports[1, 2] from abroad state that secondary shock is responsible for 60 to 80 per cent of all deaths occurring from burns. This would seem to indicate that in spite of important advances in the physiology of shock further studies of this phase of the pathology of burns still offer the greatest opportunity for lowering the mortality rate.

Previous studies by other authors have shown that the fundamental cause of this secondary shock is a change in capillary permeability, resulting in the extravasation of a large part of the circulating blood plasma. The characteristic blood picture, following this extravasation, consists in a high concentration of red blood cells and a low concentration of plasma protein in the circulating plasma. Saline and dextrose solutions not only fail to aid the situation, but, as was shown by Minot and Blalock,[3] actually increase the disturbance by washing out the plasma proteins which are required to keep such solutions in the vessels. This increases edema within the perivascular tissues. Whole blood, on the other hand, has the disadvantage of adding erythrocytes to the circulating fluid that already shows hemoconcentration, with an attendant increase in the viscosity. There is now general agreement that plasma transfusion is the most logical type of replacement therapy and that it has given the best clinical results.[4, 5, 6, 7]

With the object of applying these advances in physiologic knowledge to the specific problems of individual burned patients, we undertook a quantitative control of the fluid shift.[8] Serial hematocrit and plasma protein determinations were made at frequent intervals following the burn. Plasma volume changes were calculated on the assumption that the total volume of circulating red cells was relatively constant during the period of observation, and that the plasma volume amounted to 5 per cent of the body weight. While neither of these assumptions is strictly correct, it was possible by means of this method to calculate quite accurately how large a plasma transfusion would be needed

* Read before the American Surgical Association, White Sulphur Springs, W. Va., April 28, 29, 30, 1941.

to restore the hematocrit and plasma protein levels to normal. The formulae are expressed as follows:

$$\text{Observed plasma volume} = \frac{(100 - Ho)\, Hn \times 0.05W}{(100 - Hn)\, Ho}$$

$$\text{Plasma protein deficit in grams} = 3.5W - \frac{W(100 - Ho)\, Hn\, Po}{2(100 - Hn)\, Ho}$$

W = Body weight in kilograms
Ho = Observed hematocrit, per cent cells
Hn = Normal hematocrit for patient
Po = Observed plasma protein concentration, grams per cent

The deficit in grams of protein multiplied by 14 gives the cubic centimeters of plasma required for transfusion. The "normal" hematocrit (Hn) for each

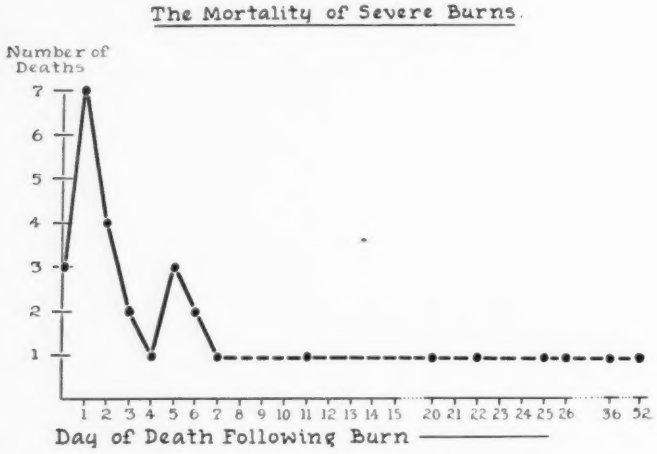

FIG. 1.

patient must be estimated, in cases of anemia and polycythemia on the basis of the figure at which the hematocrit stabilizes after the period of fluid shift. Errors in making this estimation affect the height of the curve but do not affect its shape significantly.

It was found, however, that when large plasma transfusions were administered soon after the receipt of the burn, there was not as great a rise in the plasma volume as had been anticipated and, furthermore, as a rule the rise that was obtained proved to be only temporary. This evidence of continued extravasation of protein, during this phase, suggested that the method could be used to study the duration of the abnormal capillary permeability believed to cause this type of shock. By administering large plasma transfusions at varying intervals after the receipt of the burn, we estimated that a period of about 40 hours was required for the recovery of the capillary walls to their normal state of permeability for proteins under these conditions.

It was evident that an agent should be sought which would decrease capillary permeability, or at least shorten its duration. The method which has just

been outlined was well-adapted to testing such agents. During the past year, we have applied it to a study of adrenal cortical extract known as Eschatin.*

Adrenal cortical hormone preparations were suggested in the treatment of traumatic shock by Swingle and others and have been used in the treatment of burns by several investigators.[8, 9, 10, 11, 12] The results were usually stated as being favorable, but in all cases in the literature, except those reported by Scudder,[11] the evaluations rested mainly on bedside observations. Some of these authors employed it in the first 48 hours to combat the fluid shift, and others employed it later in the period of toxemia.

During the past two years, we have had the opportunity of studying 26 patients with extensive burns. In each case, the affected area was débrided, tanned, and the patient placed under a thermoregulated cradle. Hematocrit and plasma protein levels were determined at six-hour intervals for 48 hours, and less frequently thereafter. Plasma chlorides, carbon dioxide combining power, and nonprotein nitrogen were also determined at frequent intervals. Plasma volume changes were calculated, as analyses were made. In most instances, a continuous infusion of citrated blood plasma diluted with an equal volume or more of 5 per cent dextrose in distilled water, or with 0.85 per cent NaCl when needed, was given in adequate amounts to keep the hematocrit below 55 and the plasma protein level above 6 Gm. per cent. In seven cases, it was possible to start the administration of adrenal cortical extract within a few hours after the injury, and to get specimens regularly throughout the period of fluid shift. These burns ranged in extent from 9 to 65 per cent of the body surface. There was extensive third degree involvement in each instance. The cortical extract (Eschatin) was administered intravenously in a dosage of 5 to 10 cc. every six hours for the adults, and in proportionate or larger amounts for the children. Five of the patients received amounts of plasma comparable to the calculated plasma loss. Two of the patients received decidedly smaller amounts. Of the five patients in the first group, three showed a sharp rise in the calculated plasma volume between the eighteenth and thirtieth hours, with levels at or close to normal between the twenty-fourth and thirtieth hours. One showed an early rise of 15 per cent, followed by a considerable "lag-period." One showed a very marked rise from the eighteenth to the twenty-fourth hours, followed by a relapse which may have been associated with symptoms of venous obstruction in the right leg, which finally resulted in gangrene of the foot. Of the two patients who received only small amounts of plasma, one showed no benefit from Eschatin whatever, and the other showed fairly complete retention of the plasma after the twenty-fourth hour. The patient who failed to respond at all had several concomitant diseases, including chronic alcoholism and congenital syphilis, the influence of which it is impossible to evaluate at present. Details are given in the curves (Figs. 2 to 8 inclusive) and in the case reports.

In comparing the curves of these patients with patients who had burns of

* The Eschatin used in this study was obtained through the courtesy of Parke, Davis and Company.

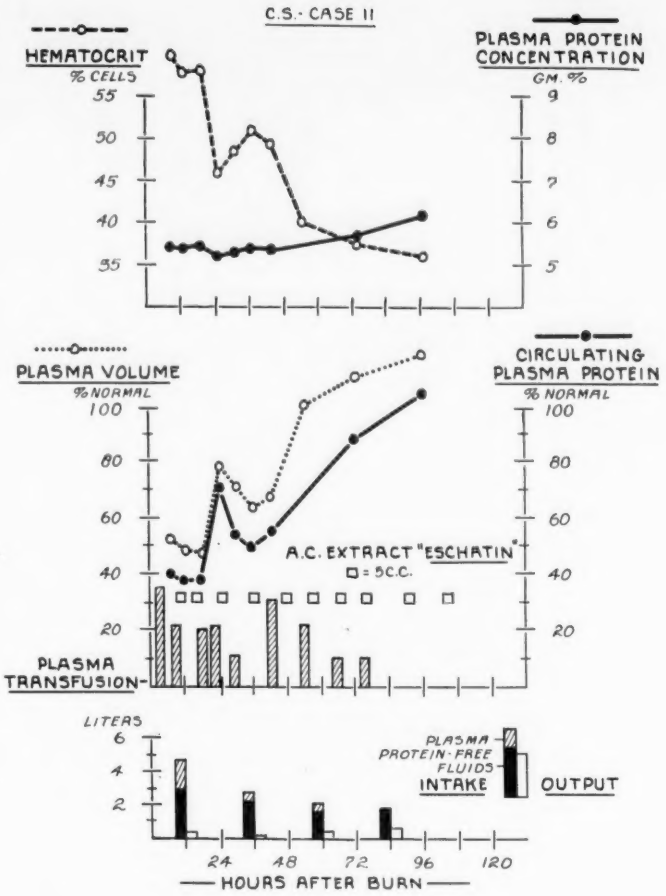
C.S.-CASE 11
HEMATOCRIT
% CELLS
55
50
45
40
35
PLASMA PROTEIN CONCENTRATION
GM. %
9
8
7
6
5
PLASMA VOLUME
% NORMAL
100
80
60
40
20
CIRCULATING PLASMA PROTEIN
% NORMAL
100
80
60
40
20
A.C. EXTRACT "ESCHATIN"
□ = 5C.C.
PLASMA TRANSFUSION
LITERS
6
4
2
PLASMA-PROTEIN-FREE FLUIDS
INTAKE
OUTPUT
24
48
72
96
120
HOURS AFTER BURN

Fig. 2.

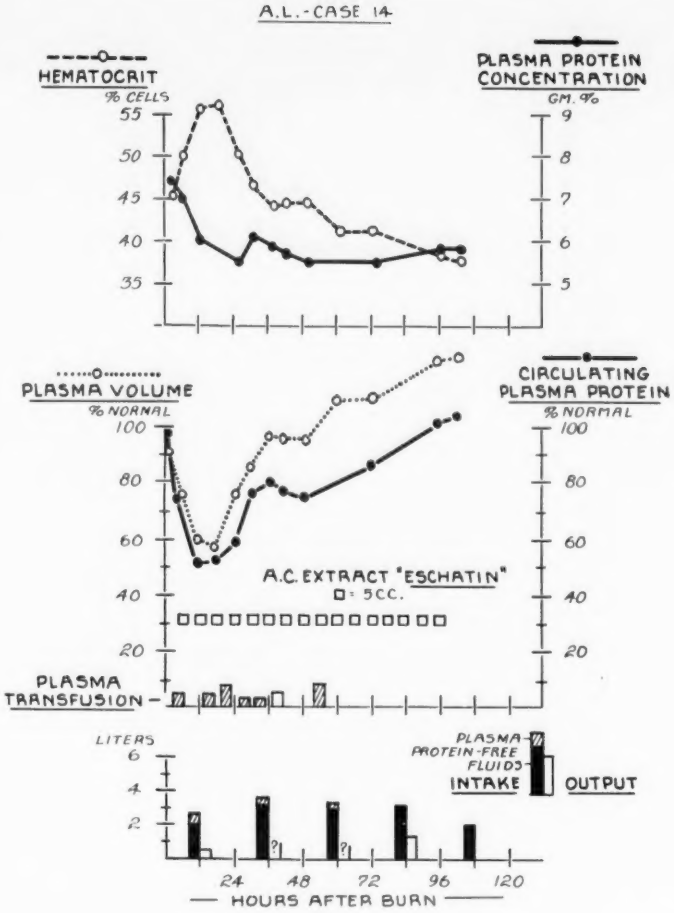
A.L.-CASE 14
HEMATOCRIT
% CELLS
55
50
45
40
35
PLASMA PROTEIN CONCENTRATION
GM. %
9
8
7
6
5
PLASMA VOLUME
% NORMAL
100
80
60
40
20
CIRCULATING PLASMA PROTEIN
% NORMAL
100
80
60
40
20
A.C. EXTRACT "ESCHATIN"
□ = 5CC.
PLASMA TRANSFUSION
LITERS
6
4
2
PLASMA-PROTEIN-FREE FLUIDS
INTAKE
OUTPUT
24
48
72
96
120
HOURS AFTER BURN

Fig. 3.

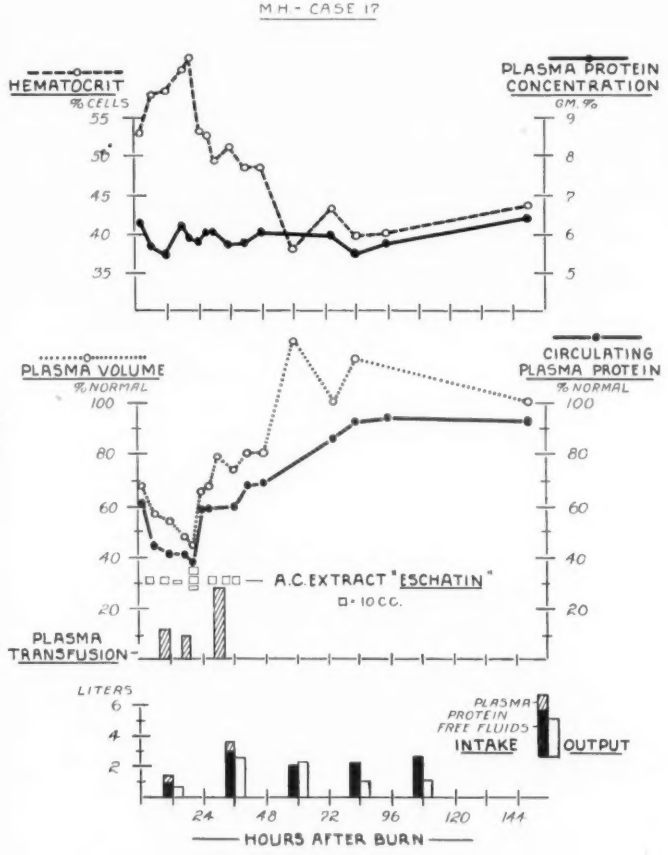
M.H. - CASE 17
HEMATOCRIT
% CELLS
PLASMA PROTEIN CONCENTRATION
GM. %
PLASMA VOLUME
% NORMAL
CIRCULATING PLASMA PROTEIN
% NORMAL
A.C. EXTRACT "ESCHATIN"
□ = 10 CC.
PLASMA TRANSFUSION
LITERS
PLASMA PROTEIN FREE FLUIDS
INTAKE
OUTPUT
HOURS AFTER BURN

FIG. 4.

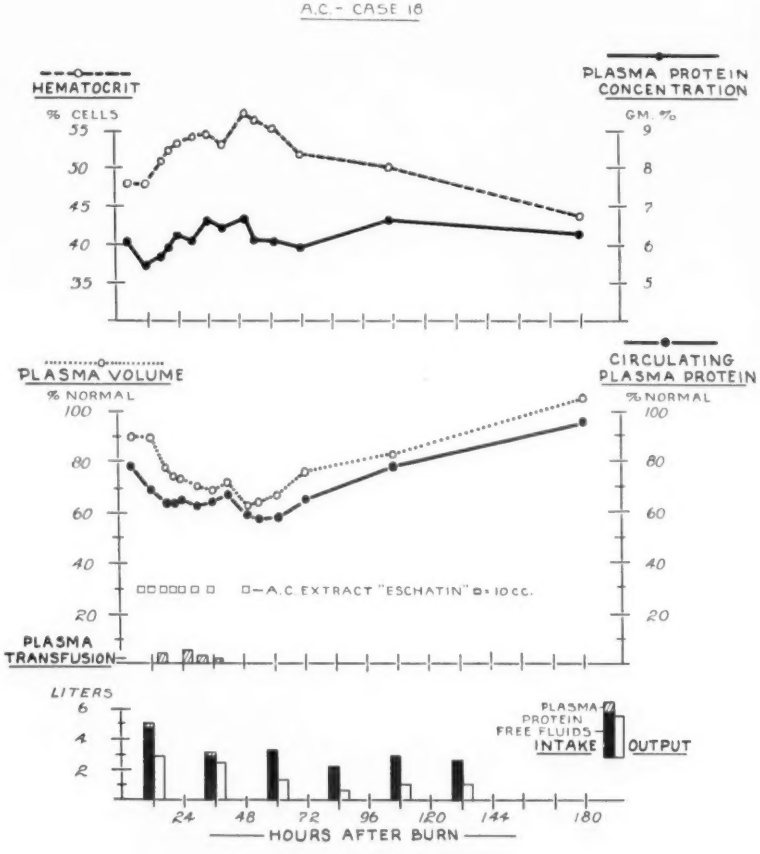
A.C. - CASE 18
HEMATOCRIT
% CELLS
PLASMA PROTEIN CONCENTRATION
GM. %
PLASMA VOLUME
% NORMAL
CIRCULATING PLASMA PROTEIN
% NORMAL
□□□□□□ □—A.C. EXTRACT "ESCHATIN" □ = 10 CC.
PLASMA TRANSFUSION
LITERS
PLASMA PROTEIN FREE FLUIDS
INTAKE
OUTPUT
HOURS AFTER BURN

FIG. 5.

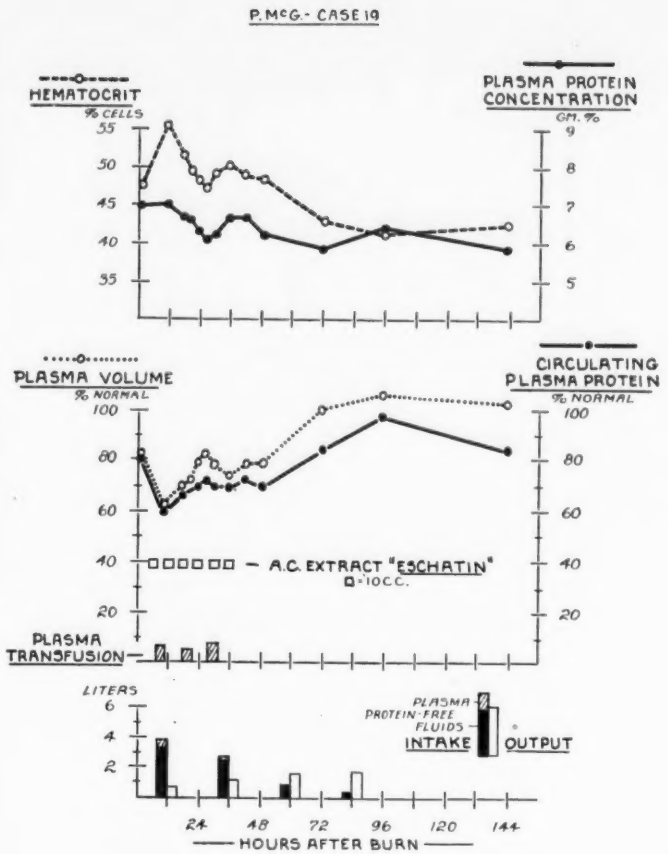

FIG. 6.

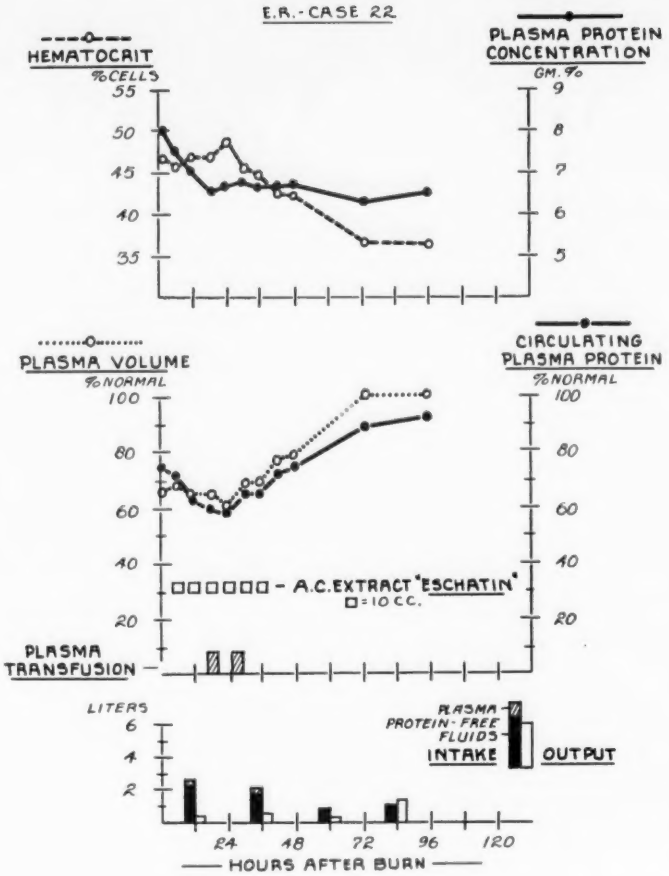

FIG. 7.

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Number 6

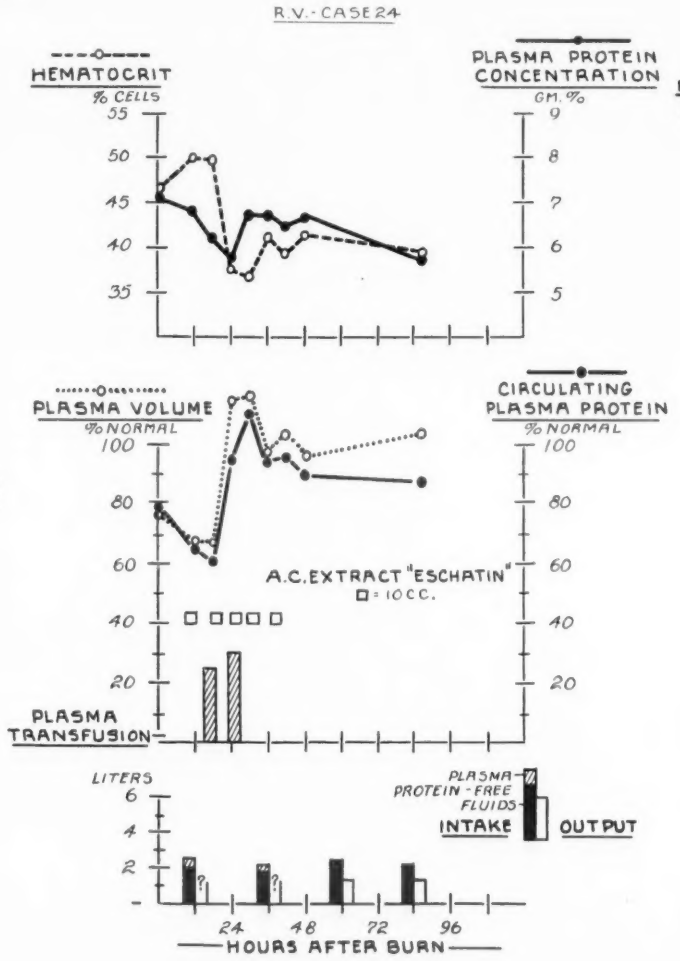

Fig. 8.

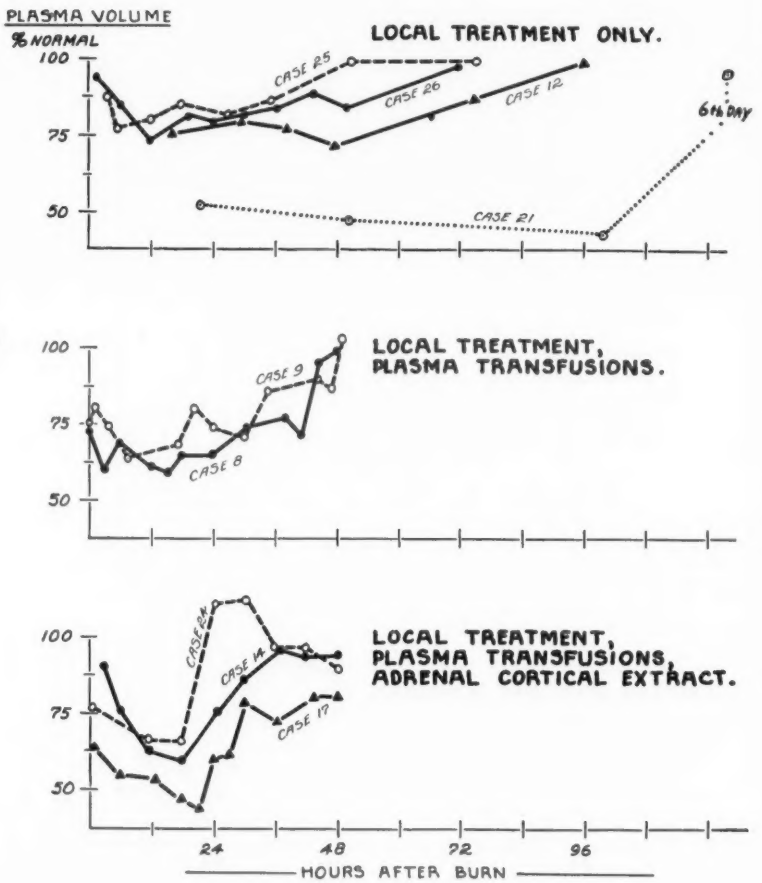

Fig. 9.

comparable extent and who received comparable amounts of plasma but no cortical extract, it appears that in no case in the latter group was it possible to obtain a substantial rise in the plasma volume of a severely burned patient before the thirty-sixth hour, without inducing a rapid loss of protein. This is well-exemplified in cases reported previously.[6] The average loss of transfused plasma in the critical period between the eighteenth and forty-second hours after the receipt of the burn was 53 per cent for four patients who did not get cortical extract, as compared with 28 per cent for four patients who did receive it. Less plasma was required in the second group and yet the plasma volume was brought back to normal considerably earlier.

Changes in plasma volume in relation to type of treatment are shown in Figure 9. The first group received local treatment only. Two patients, with burns involving less than 5 per cent of the body surface, showed a plasma volume returning to normal at 48 and 72 hours respectively, after the injury. Two patients with somewhat more than 10 per cent of the body surface burned showed normal plasma volumes on the fourth and sixth days after the injury. In the second group, two patients with extensive burns (15 and 20 per cent, largely third degree) received adequate transfusions of plasma. The circulation was restored to normal in less than 50 hours. In the third group receiving adequate transfusions of plasma plus adrenal cortical extract, the circulation was restored to normal between the eighteenth and thirtieth hours.

CASE REPORTS

Case 11.—C. S., colored, female, age nine, admitted to the Graduate Hospital of the University of Pennsylvania, October 19, 1940, with second and third degree burns of practically all the skin from the knees to the chin, including much of the arms. The burns were due to ignition of clothing by an oil stove.

Under light gas anesthesia, the burns were débrided and tanned with silver nitrate 10 per cent and gentian violet 1 per cent and 500 cc. of plasma started with the aid of a phlebotomy. Within an hour of the accident, all the extremities were cold and pulseless. Six hours later circulation showed distinct improvement which continued until all extremities were warm. No marked diuresis. Right leg swelled very markedly and the foot became gangrenous on the fourth day. Patient died on the fifth day with corrected fluid balance but a mounting nonprotein nitrogen concentration in the blood. Autopsy revealed toxic degeneration of the liver and acute diffuse glomerulonephritis.

Case 12.—C. B., white, male, age 53, burned by flaming gasoline on hands and forearms, largely second degree, with small areas of third degree. Burned areas débrided and tanned, Resorcitanol* on right hand and arm, 1 per cent gentian violet on left hand and arm. Temperature 101° F. on first day, slightly less than 100° F. for a week, and normal thereafter. Tests of liver function indicated some impairment on third and fifth days. Plasma volume normal and edema subsiding on fourth day. Apparently a case of polycythemia with a "normal" hematocrit of 56 per cent cells. Recovery was uneventful, discharged on thirty-third day.

Case 14.—A. L., white, male, age 48, about 40 per cent of body surface sustained second and third degree burns from fire. Areas involved included lips, scalp, neck, both shoulders, all of back, dorsa of both arms, forearms and hands, both thighs posteriorly, and left leg laterally. Primary shock was treated with morphia and heat. With the

* Supplied by Dr. Roy D. McClure and Dr. F. W. Hartman of the Henry Ford Hospital, Detroit.

patient under anesthesia, the burned areas were thoroughly scrubbed, débrided and tanned with 10 per cent silver nitrate and 1 per cent gentian violet. Continuous intravenous infusion was given under chemical control for 80 hours. Fluid imbalance was corrected between the eighteenth and thirtieth hours. Leakage of protein from capillaries continued until the forty-eighth hour. Nonprotein nitrogen in blood rose steadily to 126 mg. per cent on fourth day, and bilirubinemia was 4.6 mg. per cent. Patient died on fifth day without regaining consciousness. Necropsy showed pneumonia, with extensive consolidation of both lungs, necrosis of the liver, and nearly normal kidneys.

Case 17.—M. H., white, female, age 12, admitted to the Graduate Hospital of the University of Pennsylvania, December 31, 1940, with second and third degree burns of abdomen, lower chest, sides of buttocks, and smaller areas on the back, legs, elbows, and wrists. Patient's clothing had caught fire.

Under light anesthesia, the burned areas were débrided and tanned with 10 per cent silver nitrate solution and 1 per cent gentian violet solution.

The patient had a distinct diuresis after the first 24 hours. Her circulation was restored rather promptly but her subsequent course was very prolonged due to anorexia and resulting inanition. The burned areas are largely epithelialized at the end of four months.

Case 18.—A. C., white, male, age 45, sustained second and third degree burns on right leg from ankle to upper third of thigh. Tanned with silver nitrate and gentian violet. The graphs (Fig. 5) show extravasation of protein up to the forty-eighth hour. Recovery from local injury was extremely slow but uneventful.

This patient was a congenital luetic with cardiac insufficiency and a chronic alcoholic.

Case 19.—P. McG., white, male, age 56, was burned on both legs while intoxicated. Apparently his trousers were ignited from a bonfire. The burned areas were débrided and tanned with 10 per cent silver nitrate and 1 per cent gentian violet. His circulation was well-maintained throughout his course. Epithelization was practically complete at the end of 15 weeks.

The curves (Fig. 6) show a greater percentage loss of protein given by transfusion than was observed in other patients receiving Eschatin.

Case 21.—B. W., colored, female, age three, admitted to the Graduate Hospital of the University of Pennsylvania, January 16, 1941, following a burn of both legs and forehead caused by the explosion of an oil stove. She was débrided and tanned with 10 per cent silver nitrate and 1 per cent gentian violet. She received no plasma transfusions and showed a hemoconcentration which was corrected spontaneously on the sixth day. Clinically, her condition was never alarming. The burned areas ultimately healed after ten weeks.

Case 22.—E. R., colored, female, age 40, admitted to the Graduate Hospital of the University of Pennsylvania in February, 1941, following ignition of her clothing. The burned area included the entire right flank and large portions of the abdomen, back, right breast, and left leg. Under light anesthesia, these areas were débrided and tanned with 10 per cent silver nitrate solution and 1 per cent gentian violet solution.

Her circulation was well-maintained throughout her illness. She was largely epithelized after eight weeks.

Case 24.—R. V., white, female, age six, admitted, February 24, 1941, with second and third degree burns from flame on the right side of the trunk, right axilla, and right arm. The burned area, about 15 per cent of the body surface, was débrided and scrubbed thoroughly with tincture of green soap and sterile water, then tanned with 10 per cent tannic acid while the patient was under ether anesthesia.

Plasma transfusions between the twenty-second and twenty-seventh hours restored the plasma volume. A slight leakage of protein continued until the forty-second hour.

Case 25.—H. E., white, male, age 45, scalded on right side from armpit to brim of pelvic girdle, a second degree burn involving less than 5 per cent of body surface, tanned

with 1 per cent gentian violet. Plasma volume fell to 76 per cent of normal at 6 hours and came back to normal at 48 hours.

Case 26.—J. A., white, male, age nine, burned by fire on outer aspect of right thigh. Second degree burn involving about 3 per cent of body surface, treated with sulfathiazole powder without a tanning agent. Plasma volume returned to normal on the third day.

Discussion.—The data presented have been obtained from clinical material and the cases lack the uniformity necessary for a well-controlled experiment. There is little evidence to indicate that adrenal cortical extract increased plasma volume *per se*. No striking recovery of plasma volume was noted unless large amounts of plasma were administered. Apparently, it reduces the permeability of the damaged capillaries and, thereby, it enables the vascular compartment to retain a large proportion of the plasma protein placed in it by transfusion. The graphs indicate that the change in the capillary permeability between the eighteenth and the thirtieth hours is relative and not absolute as most of the curves show small secondary declines in the latter part of this period. Two patients who showed a marked extravasation of protein after the thirtieth hour were chronic alcoholics. Whether this is an important factor must be decided by future observations.

This reduction in the permeability of damaged capillaries in the patient is similar to the experimental results of Heuer and Andrus[13] who studied shock produced by the injection of extracts from closed intestinal loops. In both man and animal the beneficial effect of adrenal cortical extract is most striking when given simultaneously with an adequate transfusion (plasma in the present study).

Regardless of whether one believes in a circulating toxin as the principal cause of visceral damage observed in patients dying from the fourth to the tenth day after burns, it must be admitted that most of these changes can be brought about by stagnant anoxia, which may occur in traumatic shock from any cause. An agent which will reduce capillary permeability is valuable, therefore, to prevent or, at least, to shorten the period of stagnant anoxia, with a view to avoiding visceral injury as far as possible.

Adrenal cortical extract, in the dosage used, results in a marked chloride retention. Two of the patients developed hyperchloremia, although neither of them received excessive amounts of saline solution, as judged by our experience with patients not given the extract. Two patients who died during the toxemia phase received Eschatin up to the time of death. It did not prevent the development of the symptoms characteristic of this phase of burn pathology.

CONCLUSIONS

(1) Adrenal cortical extract has been of value in the treatment of the fluid shift occurring in this group of patients after severe burns.

(2) When it is effective, it appears to act by reducing the permeability of the capillaries for plasma protein, as early as the eighteenth hour.

(3) The data obtained do not indicate that it is of value in restoring the

circulating plasma volume, unless adequate plasma is added to the circulation by transfusion at the same time.

(4) It is recommended for use in the treatment of patients with extensive burns.

(a) To reduce the amount of plasma required to restore the circulation to normal.

(b) To reduce the amount of plasma protein which enters the interstitial fluid.

(c) To shorten the period of stagnant anoxia with a view to reducing visceral injury to a minimum.

(5) A marked chloride retention occurs in patients receiving adrenal cortical extract. Such patients should not be given any sodium chloride unless indicated by chemical analysis of the blood.

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DISCUSSION.—DR. ROY D. MCCLURE (Detroit, Mich.): My interest is like Doctor Lee's, in that we have had a group with us who have been interested in this subject ever since Doctor Davidson, as my resident surgeon, renewed the interest of the world in the subject of burns. At the present time Doctors Lam and Harkins are carrying it on quite extensively.

One thing that has impressed us has been the difficulty, throughout the world perhaps, in getting autopsies on patients who have died of burns. They are all coroner's cases, as they are accident cases. "Any man knows that man died of a burn." Now, we

are beginning to get more autopsies and I think we will learn something from the pathologic material, and more as time goes on.

This slide represents a section of the left adrenal gland, showing hemorrhage in the corticomedullary zone. Numerous erythrocytes are seen between the cords. This section was obtained from a girl age four years, who died 11 days after severe scalds with sepsis and a penetrating duodenal ulcer (Curling's ulcer). This case was previously reported in Surgery in April, 1938, by Dr. H. N. Harkins who is now with us. It and somewhat similar cases reported in the literature demonstrate that, in some instances, there may be a definite anatomic basis for the treatment advised by Doctor Lee to-day.

Another point that we in our clinic have felt would help a great deal in the studies on heparin, pituitary, and in the treatment of adrenal extracts is to have the manufacturer's name given in the paper. As we know now, the adrenal cortex probably has about as many chemical functions or chemical compounds evolved from it as does the pituitary gland.

Another point to be borne in mind is that the adrenal cortex does not yield just one substance. Corticosterone, desoxycorticosterone acetate, the compounds E and F of Kendall, the S fraction of Reichstein, and the so-called amorphous fraction are all to be considered. These different compounds in many cases have antagonistic action. Thus, desoxycorticosterone is inactive in glucogenesis and in protecting the liver against certain poisons such as carbon tetrachloride, while compound E is fully active in both regards. In crude extracts, the action of the various fractions may neutralize each other. It would seem important then, in the present state of therapeutic use of these compounds, to state always, as Doctor Lee has, just which extract has been used in the treatment of a particular case. Only in this way can we draw accurate conclusions and avoid sweeping assumptions on the action of the adrenal cortex from results from just one of its fractions.

We are noticing this in our work with heparin.

Doctor Lee and his associates have made a real contribution. We have in the last year used particularly their formula, which we find of greatest benefit, and we find that we do not waterlog our patients. We can recommend very highly the formula which they have put out.

(Slide) This, of course, is the liver lesion shown by autopsy as a result of burns.

(Slide) This is a very extensive burn, one that we felt would have died formerly, but we have used the formula of Doctor Lee, and that patient made a very beautiful recovery.

Dr. Alfred Blalock (Nashville, Tenn.): This is a very important subject. It seems to me that this is the most convincing evidence as to the effectiveness of adrenal cortical extract that has been offered since the original publication of Heuer and Andrus.

I would like to remind you that there is a great individual variation in the reaction of patients to trauma and to burns, and that it is exceedingly difficult to be certain as to the effectiveness of any method of therapy.

(Slide) However, there is no doubt whatever as to the effectiveness of plasma or serum. Doctor Wolff has already pointed out an observation that we have emphasized previously, and, that is, when one introduces a solution of crystalloid in the presence of gross capillary damage, one gets a marked dilution of the protein content of the blood plasma, whereas such does not occur if blood serum or blood plasma are given.

(Slide) I would like to introduce one other point which may be quite debatable. In most text-books, it is stated that the patient in shock, whether due to burns or not, should be warmed, and I am quite certain that that is true in most instances of shock. But we should remember that the blood volume is reduced, in many instances of traumatic shock, very markedly, that it is reduced throughout the body, but more so in the periphery, for the reason that the vital structures, the brain, the heart, the adrenals, need blood very badly, and the proposition that I submit is that it is possible to do harm by trying too vigorously to warm the extremities, unless one at the same time supplements the blood volume by giving of plasma and serum or whole blood.

I shall not go into these experiments in detail, but shock was reduced by the removal of blood until the blood pressure fell to 75 Mm., and in the animals to which

cold was applied, the average survival period was 16 hours. Those in which an elevation of temperature was caused of several degrees lived only three hours and 50 minutes.

(Slide) The type of blood pressure chart that one gets when heat is applied is illustrated. Heat was applied here following hemorrhage. The animal died about an hour and one-half later, the blood pressure falling very suddenly.

(Slide) This is the type of result that one gets when cold is applied. It was applied here, following the hemorrhage, and the animal lived about seven hours.

(Slide) Those experiments were on hemorrhage, and several results were obtained when trauma to the extremity was carried out. Please bear in mind that we are not advocating the grueling of the patient, but we are saying that very vigorous attempts, such as the placing of many hot water bags about the extremities, should not be carried out unless one can at the same time supplement the reduced blood volume.

Dr. William D. Andrus (New York, N. Y.): I have been extremely interested in the paper of Doctors Lee, Rhoads, and Wolff, and in their results.

I should like to review, cursorily, the evidence in the paper which I had the privilege of presenting, by invitation, with Doctor Heuer at the Toronto meeting in 1934. We were using intravenous injection of aqueous extract of obstructed intestinal loops in studies on the possible toxemia of intestinal obstruction. I may say, however, that the same results can be duplicated with other toxins.

Two points stood out with regard to the use of adrenal cortical hormone. One has been so suggestively followed in the work which has been presented to-day on patients, namely that protein plasma which is introduced in the presence of a toxemia is quite lost from the circulation, whereas when this is done with the simultaneous administration of adrenal cortical extract this is largely retained. However, in using this on a few patients, but without a massive transfusion of plasma, as the authors have used, we have not been able to produce such striking results. I think the fault is largely ours.

I would, however, point out this note of caution, which reenforces what Doctor Blalock has said, that the reaction of various patients to varying grades of trauma is greatly different, and I would stress the fact that there is a point at which the permeability of the capillaries becomes apparently irreversible. We can illustrate that quite clearly by a somewhat crude experiment which we have done. We have utilized the vascular bed as one side of the membrane and the lymph as the other side. After the injection of a variety of toxins, the lymph flow is increased. First, its albumin content is very markedly increased, and then the globulin, until you reach a point where the lymph has practically the same composition as the blood plasma, and at about that point or earlier one also sees red cells in the lymph. When such a degree of permeability, or probably a degree a good deal less than that, has been reached, it is irreversible, and nothing put in in the way of plasma can be retained.

Another point which was confirmed in the work which we did, which has been suggested previously by the increased resistance of animals to such things as diphtheria toxin after the administration of adrenal cortical hormone, leads me to make the suggestion that the administration of this substance should not be delayed until the plasma necessitates—no doubt many have carried it out in this way—but that immediately, as an emergency measure, the patient should receive an intravenous treatment—intravenous injection of adrenal cortical hormone.

The method of administration seems to me to be of importance. In the animals which we used, we had a sudden large introduction of toxins in the circulation, rather than a slow, relatively slow, and continued injection. There I think the set up in the experiment was easier to control. One of the statements which was made in the vernacular of the laboratory, at the time, was that not only was the toxin in the circulation in burns and intestinal obstructions but also the factory of the toxin.

I am very hopeful for the further continuation of this work.

Dr. Robert Elman (St. Louis, Mo.): Dr. Lee asked me to discuss this paper and I am very happy to do so because the evidence presented is most convincing that adrenocortical extract has a therapeutically beneficial effect in the treatment of severe burns by decreasing the amount of plasma necessary to effectively restore the circulation to a safe level; I say this even though our own earlier observations were negative. During the past five years about 150 cases of severe burns were studied and treated at the St. Louis City Hospital; Dr. Rowlette will report these cases in considerable detail in the near

future. Although adrenocortical extract was used in many of these cases without any observable effect it is probable that insufficient doses were given and also that the extracts at that time were less potent than the ones now made.

The accurate evaluation of the effectiveness of adrenocortical extracts is extremely difficult because they contain such a great number of different active principles as pointed out so well by Dr. McClure. The isolation of the various sterones in the adrenal cortex moreover is handicapped by the fact that all of the adrenals removed from all of the cattle in this country in one year would, it is said, yield only 1000 grams of cortical extract. We must rely therefore upon the synthetic chemist who thus far has produced but few, e.g., desoxycorticosterone.

May I express my great admiration for the manner in which these cases were studied by Dr. Lee and his associates; they represent to me an ideal pattern for accurate clinical investigation.

Dr. Walter Estell Lee (closing) said that this clinical study is presented because of its timeliness. Events of the not too distant future may lend national importance to the subject of burns. Colonel Kirk and Commander Hook told us yesterday the probable incidence of this type of injury that might be expected in the armed forces during active combat. Mr. Broster was anything but reassuring in his description of burns suffered by civilians in a nation at war. We must recognize that present day warfare is marked by incendiary missiles, exploding petrol, and sheets of flame that envelop soldier and civilian alike.

My own interest in this subject began by treating the victims of Teutonic fury in 1915 and 1916—petrol distributed by the *"flammenwerfer."* At that time the mortality was appallingly high, occurring within the first two or three days, and in all probability during the period which we now know as the phase of secondary traumatic shock. Fortunately, we do know more about the treatment of this type of shock, whether it be due to trauma or to heat. Yet, our mortality figures in a series of 190 cases treated in civilian life during the last decade show that 53 per cent of all the deaths occurred during the first three days, and that 77 per cent occurred during the first week. Nearly all of these deaths may be attributed to traumatic shock, and the few beyond the fifth and sixth days to toxemia.

That none of the cases in this group died during this period of traumatic secondary shock we feel is at least significant, and warrants a further study of the possibility of preventing, or at least shortening the duration of this period of circulatory impairment.

BOMB EFFECTS

THE effects of blast had been the subject of a good deal of misconception and misstatement. When an explosive detonates, a certain amount of solid substance is converted almost instantaneously into a very much larger volume of gas. When this takes place in the metal casing of a bomb a pressure is set up, variously estimated at from 100 to 600 lbs. per square inch, as a result of which the bomb casing bursts and the gas by expansion imparts pressure to the surrounding atmosphere. The blast wave constituted by this expanding zone of pressure moves extremely rapidly, especially close to the bomb. The wave of increased pressure leaves behind it a zone of rarefaction, so that behind the advancing front of the blast there is a region of decreased atmospheric pressure. If the amount of pressure is measured according to the distance from the explosion it will be found that close to the bomb the pressure is abnormally high, but that it falls off very rapidly. Taking a large bomb, no very serious pressures from the clinical point of view would be experienced 30 or 40 feet away, and at 60 or 70 feet the pressures do not really matter at all clinically, even though they might be sufficient to damage walls and windows.

—Prof. S. Zuckerman, British Medical Journal.

THE THERAPEUTIC VALUE OF PRESERVED BLOOD PLASMA *

A SUMMARY OF ONE HUNDRED AND TEN CASES

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THE USE of blood plasma or serum as a readily available substitute for whole blood transfusions has become an acceptable procedure both in this country and abroad. Plasma and serum do not require cross-matching with the recipient's blood; both may be used without regard for blood groups; and both can be safely stored for extended periods. There are many reports in the recent literature attesting to the efficacy of these materials in the treatment of patients whose circulating blood volume has been reduced by shocking procedures. Plasma is essentially comparable to whole blood in the treatment of shock resulting from hemorrhage, trauma, or burns. It is valuable in combating certain types of hypoproteinemia, in restoring the water balance of the dehydrated patient, in preventing operative shock, in checking certain hemorrhagic tendencies, and in a variety of other conditions demanding a readily available supply of protein. The therapeutic efficacy, the ease of preservation and transportation make plasma or serum the ideal substitute for whole blood in times of emergency.

In 1909, Shackell[1] described a method of rapid dehydration of frozen biologic materials. He was aware of the two fundamental principles on which the preservation depends: (1) That biologic materials will maintain their physical and chemical characteristics, if frozen rapidly; and (2) that frozen materials may be dried in a vacuum without passing through the liquid phase. He demonstrated that the brain of a rabbit infected with rabies virus could be dried in this manner and the virus recovered by passing the redissolved product into a normal rabbit brain. This method for the preservation of plasma or serum is, therefore, not a recent development, but the description of the lyophile process by Flosdorf and Mudd,[2] in 1935, gave a new impetus to its use. The lyophile process utilizes an evacuated condenser cooled with dry ice to sublime the evaporating water. Flosdorf and Mudd have also described the Cryochem[3] process using a chemical desiccant and more recently the Desivac[4] process. In 1935, Elser, Thomas, and Steffen[5] described their experience with similar methods and reviewed the literature relating to the

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preservation of bacteria and immune sera. Hartley[6, 7] has developed similar methods in the preservation of materials used in the Wassermann reaction. Greeves and Adair[8] have utilized phosphorous pentoxide as the dehydrating agent as well as mechanical refrigeration. These methods all embody the same fundamental principle and they differ only in mechanical features. The lyophile process makes use of a manifold with the containers of serum exposed to room temperature. Strumia[9, 10] and others have used an evacuated chamber in which the containers are placed.

Various modifications have been described by other authors, each having its own advantages. Hill and Pfeiffer[11, 12] have perfected the "Adtevac" process which embodies "Snap" freezing of the materials, and the moisture is adsorbed on silica-gel. Greaves and Adair[13] have also employed "Snap" freezing in their method. Hartman[14] dries blood plasma by dialysis in cellophane containers. Another method is that of Harper, *et al.*,[15] and of Edwards, Kay, and Davie,[16] in which warmed plasma is sprayed into a heated evacuated chamber condensing as a dry flaky powder. We have dried blood plasma with an apparatus which was built in our own laboratory, based on the lyophile method and this method has been extremely satisfactory.

The clinical use of plasma does not demand that it be preserved in the dry form. Wet plasma may be safely stored under sterile conditions at 4° C. for three to four months. There has been considerable discussion concerning the comparative efficacy of wet and dried plasma. When the transfusion is given for the replacement of protein and electrolytes, there is no appreciable difference. Some of the properties of wet plasma deteriorate with storage, the prothrombin content diminishes, immune bodies are perhaps destroyed, and the danger of contamination is greater than with the dried product. Wet plasma is more easily prepared and it does not require expensive apparatus. Dried plasma has the following advantages: (1) It deteriorates slowly, if at all; (2) it does not require refrigeration for storage; (3) it may be easily transported; and (4) it may be readily dissolved in a concentrated solution. The methods of storing diluted plasma[17, 18] are simple and efficient, but these prevent the use of concentrated protein solutions when they are indicated.

The relative values of serum and plasma are being widely discussed at the present time, and each has its ardent exponents. Strumia[9] has used both serum and plasma, and he feels that the latter is preferable. In his experience, serum has caused a very high percentage of reactions, but with plasma the incidence has been almost negligible. McGuinness, Stokes, and Mudd[19] observed severe reactions using lyophile immune sera. In 1939, Ravdin[20] stated that: "The frequency with which reactions have occurred following the injection of lyophile serum makes us hesitate to suggest the more general acceptance of this material." At the present time, Ravdin prefers plasma to serum. Elliot[18] has recorded 482 injections of plasma with three reactions. Alsever,[17] Brennan,[21] and Edwards[16] do not mention any untoward effects of the plasma. Aldrich, *et al.*,[22, 23] noted reactions in two out of nine injections of serum and Meakins,[24] an incidence of 33 per cent in a small group

of patients. Ravdin[25] has noted frequent chills with the use of serum. Levinson, *et al.*,[26, 27] however, reports 47 serum transfusions with no reaction. Sir Edward Mellanby[28] reports from England that serum is preferable to plasma mainly because it can be sterilized by passage through a Seitz filter. Only plasma has been used in our series of cases and there have been very few reactions.

Plasma or serum has been used in a variety of conditions during the past few years. Because of its ready availability, it has been used primarily in the emergency treatment of shock due to trauma, burns, and hemorrhage. One of us (E. B. M.)[29] has reported clinical and experimental evidence indicating that plasma is superior to either saline or acacia in maintaining the circulation in shock. Bond and Wright[30] have reached similar conclusions in the treatment of hemorrhage and traumatic shock. Theoretically, plasma should find its greatest usefulness in the treatment of burns. In the burned patient, the blood volume is reduced because of plasma loss in the burned areas, and the hematocrit becomes concentrated. McClure[31] and Trusler, *et al.*,[32] advise the use of plasma transfusions to replenish the depleted plasma volume and to combat the hemoconcentration. In traumatic shock, the preponderant loss of the circulating blood volume is due to excessive loss of plasma. Blalock and Johnson[33] have shown that the experimental animal will tolerate the loss of whole blood better than the loss of proportionate amounts of plasma. There is now increasing clinical evidence supporting the use of plasma in traumatic shock, and it has its greatest value in its immediate availability for emergency use. In acute hemorrhage, the loss of red cells is not of prime importance unless the individual has been rapidly exsanguinated. The loss of plasma, its protein, and electrolytes are of prime consideration. Brennan[21] has shown experimentally and clinically that there are adequate stores of red cells in the capillary and splenic reserves which are mobilized by improving the circulation with plasma transfusions. The efficacy of plasma in the treatment of hemorrhage has been reported by Levinson, *et al.*, Strumia, *et al.*, and others.

Plasma transfusions have a far greater field of usefulness than the treatment of emergency shock. Ravdin[20] has emphasized its value in the maintenance of the plasma proteins in patients with hypoproteinemia. The recognition of the importance of diminishing plasma proteins in surgical patients is one of the major advances in therapeutics of the past few years. The effect on wound healing;[34, 35] on maintenance of nutrition;[36] on the water balance[37] and intestinal motility are of outstanding importance. Fine and Gendel[38, 39, 40] have demonstrated the tremendous amounts of protein which may be lost in the dilated bowel of the patient with intestinal obstruction or paralytic ileus. Aldrich and his coworkers[22] have used concentrated serum as a diuretic in patients with nephrosis. Wright and Hughes[41, 42] and their coworkers have demonstrated that abnormally high cerebrospinal fluid pressures may be reduced by the intravenous injection of four times concentrated serum. The

preservation of immune sera is of established clinical value. Our clinical experience with plasma transfusions indicates that this procedure is of practical importance in many of these conditions as well as in others to be outlined.

Methods.—We have provided our supply of plasma by means of a combination blood-plasma bank. Donors are bled 500 to 600 cc. and the blood is collected into flasks containing 100 cc. of 2.5 per cent sodium citrate. If the blood is not immediately used for transfusion, it is stored in a refrigerator at 4° C. If the blood has not been used within the next 72 hours, it is then centrifuged in 250 cc. flasks under sterile precautions and the plasma is collected in pools of from 500 to 1,000 cc. The plasma is cultured both aerobically and anaerobically and then either stored in 200 cc. increments as wet plasma for early use, or preserved in the dry form by means of the modified lyophile system. Two hundred cubic centimeters of the plasma are placed in one liter Fenwal flasks for drying. The desiccating apparatus consists of an evacuated manifold and condenser cooled by a mixture of dry ice and alcohol. The plasma is layered and frozen in a similar bath of alcohol and is stored in a chest of dry ice until it is attached to the manifold. Sixteen hundred to 2,000 cc. of plasma can be dried in 24 hours with our present apparatus. The dried product may be stored in the original containers or may be transferred to smaller flasks for convenience in handling and storing. We realize that this transfer will invite criticism, but we have repeatedly cultured this transferred material without a single positive culture. The material is not stored in vacuum but is stoppered under sterile precautions and stored in the refrigerator.

The dried plasma is regenerated for use by adding sterile water or saline. As will be noted later, Ringer's solution should never be used for this purpose. If the plasma is to be injected in the concentrated form or in normal dilution, sterile water should be used. If it is to be diluted to less than normal concentration, saline should be used to preserve isotonicity. Our product dissolves readily in less than one minute and we have had no difficulty in preparing a solution of four times the normal concentration. The plasma is most frequently administered in one-half the normal concentration.

The maintenance of a supply of plasma has offered no difficulty. The plasma bank is managed on the barter system and when used is replenished by bleeding donors provided by the patient. There is always an excess of blood made available by therapeutic phlebotomies on patients with pulmonary edema, hypertension, *etc.* During the past summer, we were interested in placental blood as a source of plasma. It was possible to recover 35 to 50 cc. of unhemolized plasma from the average placenta. The placental plasma has a higher concentration of protein than the adult plasma and is more advantageous because of this. All plasma has been pooled and administered to patients intravenously without regard to blood types. The protein content of the regenerated material, dissolved to the original volume, averages 4–5 Gm. per cent of total protein. This low protein content is due to the dilution with sodium citrate.

Observations.—During the past one and one-half years, 340 plasma transfusions have been given to 110 patients (Table I). Fifty of these patients received multiple transfusions and the greatest number given to one patient was 45. The maximum amount injected at any one time was 800 cc., and one man received a total of 7,150 cc. in 12 injections. The average volume per transfusion was 268 cc. and the smallest amount injected was 30 cc. (an infant). All of the plasma has been injected intravenously using a No. 18 or 20 gauge needle, and we have attempted to regulate the flow so that the average patient would not receive more than 5 cc. per minute. Plasma may be given more rapidly in treating the patient with peripheral circulatory failure.

TABLE I

SUMMARY OF PLASMA TRANSFUSIONS

Total number of patients	110
Total number of transfusions	340
Total volume of plasma used	91,152 cc.
Average number of transfusions	268 cc.
Maximum transfusions to one patient	45
Maximum volume per patient (12 injections)	7,150 cc.

A summary of the reactions to plasma is tabulated in Table II, and the individual reactions enumerated in Table III. There have been 12 reactions in the 340 plasma transfusions using pooled plasma without regard to blood type. Nine of the patients had a chill followed by fever. The reactions of this type have been mild and the temperature has always returned to normal within two or three hours. In several of the reactions, the fever may have been caused by the underlying disease rather than the plasma. These are included because we could not make a definite differentiation. The chill usually occurred 15 to 30 minutes after the injection. Three patients have had transient urticaria associated with the transfusion. The urticaria has not been associated with other symptoms and has not required treatment. The incidence of the reactions is 3.5 per cent, which is lower than with whole blood transfusions. If only the chill reactions are included, the incidence is reduced to 2.6 per cent. The reactions have not been severe, they have not caused a diminished urinary output, and there have been no fatalities.

TABLE II

SUMMARY OF REACTIONS TO PLASMA TRANSFUSIONS

Total number of transfusions	340
Total number of reactions	12
Percentage of reaction	3.5%
Total—chills and fever	9
Per cent—chills and fever	2.6
Transient urticaria	3
Per cent transient urticaria	0.9%

No fatal reactions—all reactions have been mild and transient

The conditions for which the plasma has been given are shown in Table IV. No attempt will be made to outline in detail all of the case reports but typical case histories will be recorded for each condition. These are exemplary of the reaction in each group.

TABLE III

ANALYSIS OF PLASMA TRANSFUSION REACTIONS

Name	Diagnosis	No. of Injections	Total Volume	Dose with Reaction	Nature of Reaction
J. K.	Hemophilia	45	4,400 cc.	50 cc.	Transitory chill—temp. 39° C.
E. F.	Hodgkin's	19	3,650 cc.	125 cc.	Chill—temp. 40° C. Transitory urticaria
D. DiN.	Lymphoma	7	3,050 cc.	300 cc.—2x conc.	Mild chill—temp. 39° C.—3 hrs. after injection
C. G.	Ac. nephritis	4	900 cc.	30 cc.—3x conc.	Malaise—urticaria—no fever
M.	Chr. cholecystitis	1	300 cc.	300 cc.	Transitory chill after 10 min.
P. M.	Cirrhosis liver	11	6,100 cc.	800 cc. in 350 H_2O	Chill—temp. 38° C.
C. S.	Bleeding ulcer	1	50 cc.	Plasma mixed with blood	Chill—temp. 38.5° C.
H. D.	Ulcer with obstruction	1	200 cc.	200 cc.	Chill—temp. 39.7° C.—½ hr. later
R. B.	Bleeding ulcer	2	800 cc.	400 cc.	Mild urticaria
R. K.	Ca. stomach—phlebitis	3	1,000 cc.	400 cc.	Transitory chill—temp. 38.5° C.—phlebitis—?
M. McM.	Paralytic ileus	4	1,300 cc.	450 cc.	Chill—dyspnea in ½ hr.

No fatal reactions—no anuria following reactions

TABLE IV

SUMMARY OF PATIENTS RECEIVING INTRAVENOUS PLASMA

		No. of Cases
Traumatic and operative shock		22
Hemorrhage (postpartum—7)		20
Burns		2
Postoperative hypoproteinemia with infection		14
Postoperative hypoproteinemia with infection and paralytic ileus		12
Hepatic disease		11
Renal disease		4
Hemorrhagic disease of new-born		4
Hemophilia		3
Toxemia of pregnancy		5
Miscellaneous hypoproteinemia		
Lymphoma	2	
Vomiting	3	
Hyperthyroidism	2	
Unclassified	6	13
Total		110

Shock.—The plasma has been most useful in combating shock resulting from operations, trauma, and hemorrhage. In these conditions, it has been essentially comparable to whole blood in restoring the failing circulation.

ILLUSTRATIVE CASE REPORTS OF CONDITIONS NOTED IN TABLE IV

Case 1.—R. M. H., Hosp. No. 174098: A. N., male, age 41, was admitted, January 26, 1941, in profound shock resulting from compound fractures of both legs and multiple contusions. Blood pressure 70/40. Plasma was immediately started and the blood pressure rose to 100/40 after 250 cc. had been injected. Débridement and reduction of the fractures was then performed, while 150 cc. more of plasma were injected with maintenance of blood pressure. He received 600 cc. of whole blood postoperatively. Convalescence was uneventful.

Case 2.—Hosp. No. 173962: V. J., female, age 43, was admitted to the Strong Memorial Hospital for the removal of a large myomatous uterus. Examination revealed normal vital signs; blood pressure 160/90. There was a large, smooth, firm mass filling

the lower abdomen and extending above the umbilicus. There was minimal pitting edema of the left ankle. Operation was performed under gas-oxygen-ether anesthesia. The tumor was adherent throughout the pelvis and the resection was difficult. After 45 minutes, the blood pressure dropped to 110/70, and the patient was given 1,000 cc. of 5 per cent glucose followed by 300 cc. of compatible whole blood during the next hour. Blood pressure then fell to 90/60. She was given 400 cc. of plasma during the next two and three-quarter hours with maintenance of the pressure between 110 and 120/60. The operation lasted five hours and 40 minutes. Convalescence was uneventful. In this case, the plasma was of value in maintaining the blood pressure when 5 per cent glucose and a small amount of blood had not been sufficient (Chart 1).

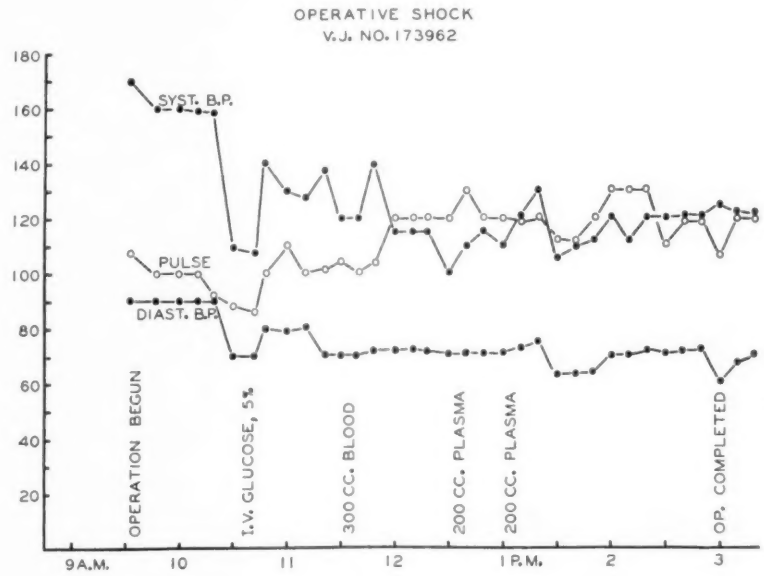

CHART 1.

Plasma has been useful in preventing operative shock.

Case 3.—S. M. H., Hosp. No. 173962: H. B., male, age 67, was operated upon for carcinoma of the ampulla of Vater with common duct obstruction. A one-stage resection was performed under drop-ether anesthesia, which included resection of the duodenum, partial resection of the head of the pancreas, a cholecystojejunostomy, jejunojejunostomy, and a gastro-enterostomy, which required six hours for completion. He was given 800 cc. of plasma and 1,000 cc. of saline beginning the second hour of operation and continued by slow intravenous drip until the end. It is interesting that the specific gravity of the plasma had begun to show dilution before plasma was started. At the close of the operation, the blood pressure was 140/60 and the pulse 100 (Chart 2).

Comment.—The rôle of plasma in preventing operative shock in this prolonged intra-abdominal operation seems definite. Diluted plasma has been used in combating operative shock rather than the four times concentrated, as reported by Hill, *et al.*[11, 12] This will be discussed in detail in a subsequent publication.

The value of plasma in treating shock due to acute hemorrhage is best demonstrated by the following cases.

Case 4.—Hosp. No. 135015: W. W., male, age 46, was operated upon for recurrent adamantinoma of the left mandible. During the difficult resection, the internal maxillary

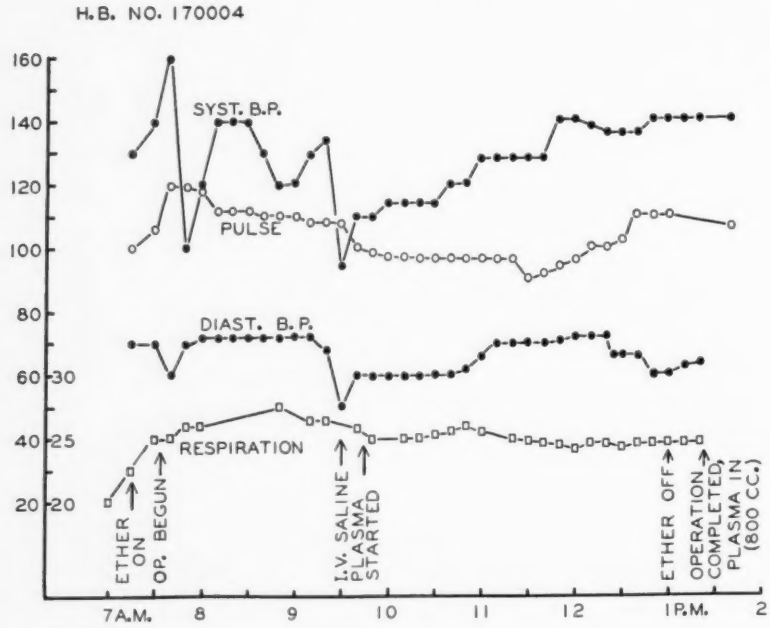

CHART 2.

artery was severed and bled profusely. When the blood pressure was 70/40, he received 400 cc. of plasma, with a temporary rise in the pressure for three hours, allowing the artery to be exposed and ligated. Two hours after the end of the operation he was given 500 cc. of whole blood. The severity of the shock was illustrated by the slow response of the blood pressure to transfusion after the bleeding had ceased. Recovery was uneventful (Chart 3).

Case 5.—S. M. H., Hosp. No. 169989: L. M. K., female, age 21, was delivered at the end of a 24-hour labor. The placenta delivered spontaneously 47 minutes after delivery of the fetus, and was followed by a very profuse and very persistent hemorrhage due to an inversion of the uterus. The patient went into shock very rapidly, and was given 1,000 cc. of 5 per cent glucose solution, with no improvement. At this time, the blood pressure was 40/0, and she received 600 cc. of plasma. The blood pressure gradually rose to 100/60 within 20 minutes, and the uterus was replaced. One hour later, the blood pressure began to fall gradually, and she received a transfusion of whole blood. The blood pressure became stabilized and the convalescence was uneventful.

Postoperative Hypoproteinemia with Infection.—There have been 14 cases which fall in this category. The clinical impression has been that these patients who developed hypoproteinemia and have associated infection are greatly improved by the addition of readily available protein to the circulation. The results in this group are not well defined, as most of the patients have

received transfusions of whole blood as well as plasma. Many of them have anorexia and all of them have been seriously ill. The following case illustrates the manner in which thrombophlebitis may be modified by hypoproteinemia.

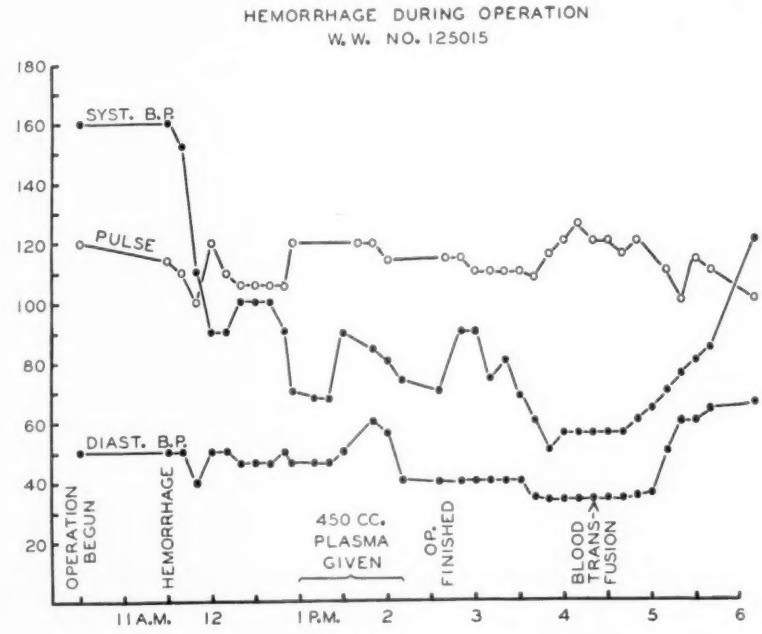

CHART 3.

Case 6.—S. M. H., Hosp. No. 45560: R. K., female, age 55, was admitted February 16, 1941. The patient had a subtotal resection of the stomach for carcinoma. Postoperatively, she developed hypoproteinemia, and on the twelfth day thrombophlebitis of the left leg developed, with hard, brawny edema. Two paravertebral blocks were performed, with a decrease in the amount of pain and a reduction of the fever. Following the second block, the edema of the leg became very soft but the swelling increased. The patient was then given two 400 cc. plasma transfusions, and the edema disappeared within 24 hours and did not recur. Her circulating protein was raised by the transfusions from 3.5 Gm. per cent to 4.7 Gm. per cent.

Postoperative Hypoproteinemia with Infection and Paralytic Ileus.—There were 12 cases in this group. They had all had intra-abdominal operations; all had had paralytic ileus; and a majority had had generalized peritonitis. These patients were not taking food by mouth and they were losing large amounts of protein into the dilated bowel. The regulation of their chloride balance was difficult, and as the blood plasma protein concentration decreased they developed edema. The continuous fall of the protein concentration and the edema can be prevented by large plasma transfusions.

Case 7.—S. M. H., Hosp. No. 68758: E. K., female, age 43, was admitted, January 31, 1941, with a diagnosis of carcinoma of the hepatic flexure of the colon, with intestinal obstruction. A preliminary cecostomy was performed February 4, 1941, and on the

following day the total protein was 4.31 Gm. per cent. She received 600 cc. of plasma in three days, and on February 10, 1941, the total protein was 3.97 Gm. per cent. On the eleventh, an ileocolostomy was performed following which peritonitis resulted. Four hundred cubic centimeters of plasma were necessary because of operative shock. Edema developed after the operation, and from the twelfth to the twenty-fourth she received 1,800 cc. of plasma in eight injections. The edema subsided, but this amount of plasma did not raise the protein level above 4 Gm. per cent until she began taking food by mouth on February 24, 1941. A right colectomy was performed, March 13, 1941, with an uneventful recovery.

Burns.—We have had the opportunity of treating only two cases of burns.

Case 8.—Hosp. No. 70243: F. F., male, age 41, was admitted, December 8, 1940, having been burned with steam 15 minutes previously. He had first and second degree burns involving the buttocks and the posterior and medial aspects of both legs from the ankles to the buttocks. He was not in shock on admission. The burns were cleaned and treated with 5 per cent tannic acid and 10 per cent silver nitrate. Twelve hours later he developed the signs of profound shock, with imperceptible pulse, and the blood pressure was not obtainable. Four hundred cubic centimeters of plasma were given, and in two hours the blood pressure was 118/78. He received 200 cc. of plasma on each of the following two days together with intravenous saline, and did not develop hemoconcentration.

Hepatic Disease.—There have been 11 cases with liver abnormalities. The majority have been cases of obstructive jaundice, and have received 200 to 400 cc. of plasma every other day to provide protein during the period of preoperative preparation and postoperative anorexia. Three cases of cirrhosis of the liver with ascites have received plasma. A male, age 67, was given 6,200 cc. of plasma dissolved in one-fourth the original volume over a 12-day period. His blood plasma protein level was unchanged and he continued to have ascites. Another man with cirrhosis formed less ascitic fluid while receiving plasma, but would again develop intra-abdominal fluid when the transfusions were stopped. One patient with a prolonged illness due to acute hepatitis was given plasma as a supportive measure.

Case 9.—R. M. H., Hosp. No. 129956: I. S., female, age 22, was in the Rochester Municipal Hospital from October 26, 1940, until January 1, 1941, with an acute hepatitis of unknown etiology. She was deeply jaundiced and developed hypoproteinemia with edema. She received 4,100 cc. of plasma in 16 injections, which maintained her blood protein above 5 Gm. per cent, and the edema subsided.

Renal Disease.—Patients with renal disease having albuminuria have received large amounts of concentrated plasma intravenously. The plasma produced a transient diuresis but the protein lost in the urine was increased and the edema recurred when the plasma was stopped. A young woman with streptococcus peritonitis and acute renal involvement was tided over a transient albuminuria with plasma during the acute phase of her infection.

Hemorrhagic Disease of the New-Born.—The clinical trial of lyophile plasma in treating hemorrhagic disease of the new-born was suggested by Dr. Sarah Hooker, and this work has been done by her. Four infants have received plasma. One patient developed hemorrhagic tendencies on the second

day of life, and the microprothrombin time was found to be six min. 19 sec./45 sec. He was given 60 cc. of regenerated plasma, which had been preserved when fresh, at 10:55 A.M.; eight minutes later the microprothrombin time was 52 sec./37 sec. One and one-half hours later it had risen to 110 sec./37 sec., and he was given 1.5 mg. of 2-methyl.-1–4 naphthaquinone in sesame oil, intramuscularly. The following day the microprothrombin time was

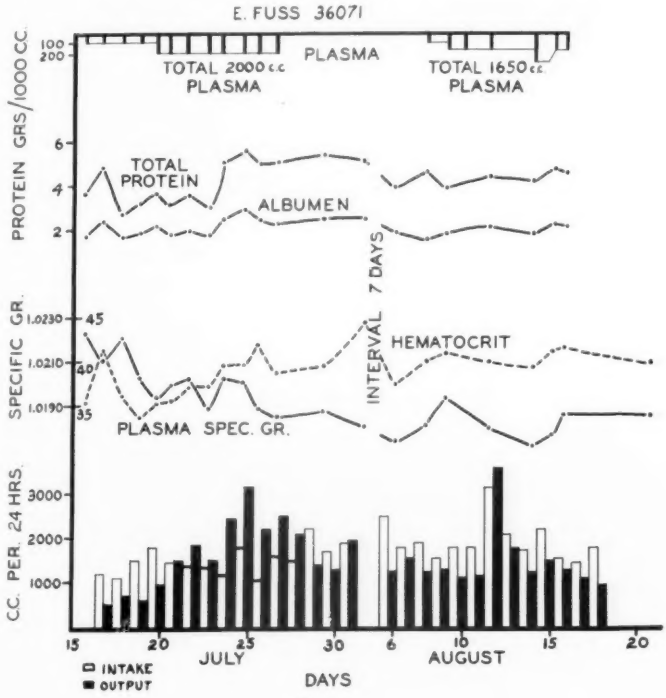

CHART 4.

33/26. All four cases have had a similar response, the plasma producing a very rapid decrease in the prothrombin time and thus tiding them over the latent period of vitamin K inactivity.

Hemophilia.—Three patients with hemophilia have been treated with plasma. One of these patients has been under treatment for several years and has received multiple whole blood transfusions. He became very sensitive to whole blood and in spite of the most careful grouping and cross-matching he had very severe reactions to each transfusion. In April, 1940, plasma treatment was started. Since that time, it has been possible to maintain the clotting time of the blood at a low level by using 50 cc. transfusions of plasma at weekly or biweekly intervals. This patient has had only one mild reaction to more than 45 injections of plasma. The cases of hemophilia are being reported in detail by Dr. John Johnson.

Toxemia of Pregnancy.—Four patients having toxemias of pregnancy,

with albuminuria and hypoproteinemia, have received plasma. The results have not been conclusive but it seems possible to prevent a critical fall in the level of circulating protein.

The patients included under the miscellaneous group received plasma as a supportive measure and the results are poorly defined. Two of the cases deserve comment.

Case 10.—R. M. H., Hosp. No. 36071: E. F., male, age 11, had been known to have Hodgkin's disease for five years. He was admitted, in August, 1940, with palpably enlarged mesenteric nodes and generalized anasarca due to hypoproteinemia. He received large amounts of plasma (Chart 4), which produced an increase in the circulating blood proteins, a diuresis and disappearance of the edema. This patient's kidney function was normal and he did not lose the injected protein in the urine (Chart 4).

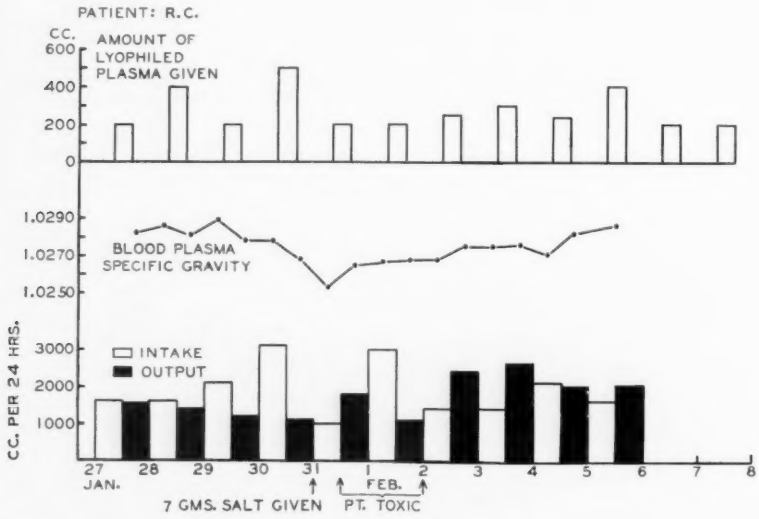

CHART 5.

Case 11.—A medical student, age 21, had a fracture of the cervical spine, with a temporary quadriplegia. Concentrated (50 per cent) sucrose solution was first used to produce dehydration. The blood plasma protein concentration then began to decrease and concentrated plasma was substituted. In this manner, the plasma specific gravity was maintained at a high level and he did not develop peripheral edema (Chart 5).

Comment.—In both of these cases the plasma was used only as a temporary measure, and it appeared to maintain the circulating protein adequately.

Concentrated plasma injected intravenously may cause a marked rise in the venous pressure. Chart 6 illustrates the rise in venous pressure which may occur as a result of the injection.

Discussion.—This series of cases, and those which have been presented by others, definitely established the use of plasma transfusions as a safe clinical procedure. Our experience indicates that plasma may be administered in large amounts and that a patient may receive multiple injections without ill effects. The incidence of reactions in this series is low, and with increas-

ing experience in the preservation and administration of the plasma, the number of reactions should be even less. It is very significant that all of the reactions have been transitory and mild.

It is of interest to speculate as to why some patients have had reactions.

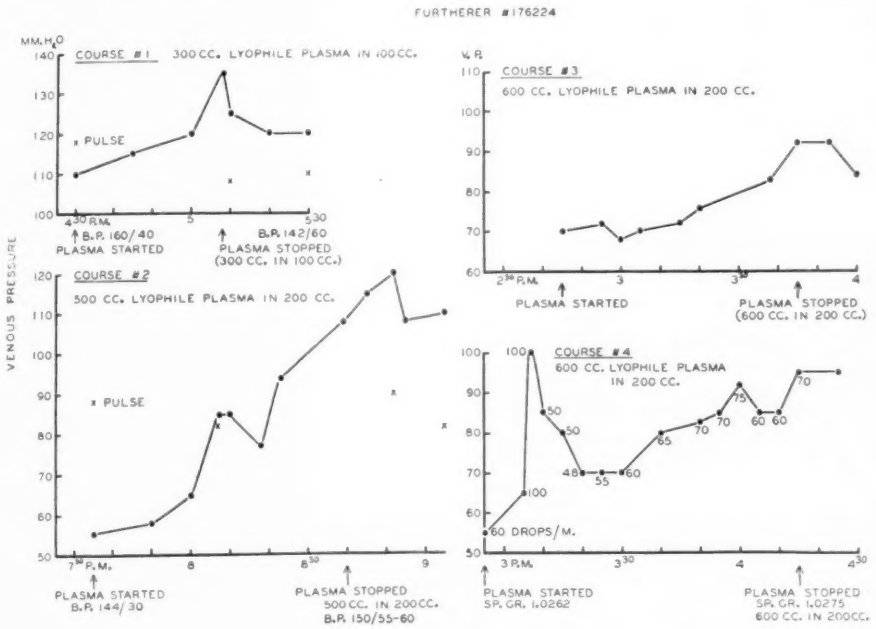

CHART 6.

When plasma is properly prepared the hemoglutinins are preserved, and there is undoubtedly some agglutination of the recipients' red blood cells. Plasma may occasionally be used which has a very high agglutinin titer, and there was one reaction probably attributable to this. This feature is not of prime importance, as indicated by the use of universal Type o whole blood transfusions. The plasma is so rapidly diluted as it enters the circulation, that the amount of red cell agglutination is minimal. Edwards and his coworkers[16] pool A and B plasma in an attempt to neutralize the agglutinins. This has not been done as there is so little danger using plasma pooled at random.

There are precautions which should be taken when preparing and administering the plasma. It should always be prepared under strictly sterile conditions and the sterility should be checked by aerobic and anaerobic cultures. Fasting donors should be used, in order to avoid excessive lipemia of the plasma. We have attempted to observe the following precautions when administering plasma.

(1) The wet plasma should not be heated above 37° C. prior to injection. DeGowin, *et al.*[50] have shown that intravenous fluids may be given when cold, and this has been true of plasma. A flocculent precipitate will form if it is heated rapidly.

(2) Dried plasma should never be regenerated with Ringer's solution, as the excess calcium may result in coagulation.

(3) Plasma should be injected slowly, especially when given in an hypertonic solution, and preferably by the drip method. The rise in venous pressure, which may occur with the injection of concentrated plasma, has been demonstrated. This might well precipitate congestive failure in the patient with a failing heart or circulatory imbalance.

(4) Transfusions of whole blood should not be given immediately after pooled plasma. The heterogenous agglutinins may cause severe reactions. If an immediate whole blood transfusion is necessary Type o blood should be used.

(5) Plasma showing excessive hemolysis should be discarded.

The plasma has been most valuable in the treatment of shock due to trauma, operative procedures, hemorrhage, and burns. The material is always immediately available, and it may be administered without the delay of typing and cross-matching. Experience indicates that plasma is as efficacious as whole blood in these acute peripheral circulatory failures. Case 1, with multiple compound fractures, illustrates its value in restoring the blood pressure to a level where operation was possible. Whole blood would have probably produced the same result but it was not available at the time. The prevention of operative shock by injection of plasma during prolonged procedures warrants emphasis. It seems advisable to inject this plasma in one-half dilution since protein can thus be slowly replaced and the patient receives sodium chloride and water to compensate for dehydration, without drawing from the reserves of extracellular water. The efficiency of plasma in combating shock due to hemorrhage was amply demonstrated in the patient with a postpartum inversion of the uterus (Case 5). Its value in maintaining the circulation and in combating the hemoconcentration in the burned patient (Case 8) has been illustrated by others.

The results of plasma transfusion in combating postoperative hypoproteinemia have been quite satisfactory. These patients have not been receiving food by mouth and their ability to fabricate protein is reduced by infection.[43] They have been losing protein into their dilated bowel and in the peritoneal exudate. Hypoproteinemia is a serious handicap to recovery. It is a cause of delayed wound healing, reduced gastric motility, and will result in edema of the stomata of intestinal anastomosis. It is not uncommon for a patient with a gastro-enterostomy to develop the signs of mechanical obstruction, which disappear when the blood plasma protein has been restored. It is often impossible to regulate the water and salt balance in these patients because of the associated edema. Large amounts of plasma must be given as they utilize proteins not only in the maintenance of blood volume but also in body metabolism.[44, 45] It is almost impossible to restore the circulating proteins to normal levels, but the frequent administration of plasma will maintain the proteins above a critical level. Fortunately, this period in the convalescence is usually temporary and the patient is soon able to take food by mouth.

The value of protein reserves in protecting the liver is comparable to the value of carbohydrates. This has been shown experimentally by Messinger and Hawkins,[46] who were able to prevent liver damage in dogs given toxic doses of arsphenamine. Miller, *et al.*,[47, 48] have been able to demonstrate a similar protective action against chloroform poisoning. The patient with an acute hepatitis (Case 9) received other supportive measures in addition to the plasma transfusions, so it is impossible to accurately evaluate its effect. However, it is probable that it was of some value. The patients with cirrhosis received only temporary benefit. They were given large amounts of plasma but there was no permanent elevation of the circulating protein.

All of the patients with renal disease had albuminuria, and plasma transfusions caused an increase in the amount of urinary protein. The increase in the circulating protein was temporary but it did produce a diuresis in those with edema. The patient with a transient acute nephritis seemed to be benefited by the plasma transfusions. She was tided over a temporary period of hypoproteinemia. In patients with nephritis and albuminuria, plasma is an efficient but expensive diuretic. When the kidney function is normal, as in Case 10, the plasma protein concentration can be more permanently increased and the edema more efficiently reduced.

There is some discussion, at the present time, as to whether or not the prothrombin is destroyed in lyophile plasma. The prothrombin time of the new-born infants could be reduced by transfusing with freshly preserved lyophile plasma. The beneficial effect was evident ten minutes after the injection. This may well be of value as a temporary procedure while vitamin K is developing its effect. This phase of plasma is being investigated by Dr. Sarah Hooker, and no definite conclusions can be made at present. It is probable that preserved plasma is much more effective than bank blood which loses its prothrombin content.[49]

The patient with a fracture of the cervical spine and paraplegia (Case 11) presented a unique problem. The blood plasma protein concentration was decreasing because of inadequate food intake and because of the high fever. Concentrated plasma provided a means of combating the hypoproteinemia and a suitable dehydrating agent.

There should be no conflict between the relative merits of plasma and whole blood transfusions. The plasma is an excellent substitute in many conditions, and its merit is due to the ease of preservation, lack of deterioration, and its immediate availability. The plasma has a great advantage in emergency work because typing and cross-matching are unnecessary. Present experience indicates that lyophile plasma may be permanently preserved. The procedures involved in preparing wet plasma are quite simple and can be undertaken, inexpensively, by small hospitals. The majority of patients should and will receive whole blood, but plasma will find its place in the emergency treatment of shock and in the transient type of hypoproteinemia. Plasma protein may be administered in larger quantities and, if desirable, in a smaller volume. Plasma may eventually be replaced by protein digests in

the treatment of hypoproteinemia but these have not as yet become entirely satisfactory.

CONCLUSIONS

(1) Pooled blood plasma may be injected intravenously without regard to blood type.

(2) The incidence of reactions to plasma transfusion is 3.5 per cent. None of the reactions have been severe.

(3) Plasma is an effective substitute for whole blood in treating peripheral circulatory failure due to trauma, operations, burns, and hemorrhage.

(4) Plasma is effective in treating temporary hypoproteinemia, especially in the surgical patient.

(5) Dried plasma retains properties which are effective in treating hemophilia.

(6) Present experience indicates that plasma, dried within a few hours after removal from the donor, is effective in treating hemorrhagic disease of the new-born.

We wish to gratefully acknowledge the assistance of Drs. Sarah Hooker, John Johnson, and Herbert Brown.

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SCIENCE AND HUMAN PROGRESS—III

The Influence of Copernicus and Galileo

IF WE study the work of Copernicus and the impact of Galileo's pronouncement that the earth is not the center of the universe upon the ideology of the world, we find that it has changed and is changing the philosophy of every human being. If correct thinking is an advantage, perhaps in the field of ideology, one of the most valuable contributions of astronomy is the reaction to the emphasis which Galileo's discovery placed upon the insignificance of Man. This, at first resented, has now become an inspiration because of the better understanding of the human intellect, its marvels, and its complete superiority to the material. To force a realization of the amazing stimulus to research and the overwhelming effect of the ideology upon Man, one needs but mention Darwin.

—A. Cressy Morrison. Transactions of the New York Academy of Sciences. Series II, 2, No. 3, January, 1940.

B.I.P.P. AND LIQUID PARAFFIN TREATMENT OF WAR AND CIVILIAN WOUNDS*

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IN THE AUTUMN of 1915, Dr. Rutherford Morison, at that time Professor of Surgery at Durham University and Surgeon-in-Charge of the Northumberland General Hospital at Newcastle, published an article upon a specific method of wound treatment. During 1914, and for the most part during 1915, the results of treatment of war wounds had been disastrous; it appeared as though surgeons had forgotten Lister's contributions and had replaced them with no constructive procedures.

The essential features of Morison's[1] recommendations were adequate exploration of the wound so that the bottom thereof might be adequately explored, and that foreign bodies, shell fragments, clothing material, and necrotic bone, or other tissue might be removed. The wound was then washed out with alcohol in order that the surface tissues might be dehydrated so that B.I.P.P. might be rubbed on and adhere to the surface of the tissues including all interstices and pockets. Morison urged that all excess B.I.P.P. should be removed. He then recommended suture of the wound insofar as this was possible.

Rutherford Morison made clear that his aim was the institution of "curtain" drainage, and that for this purpose he relied upon the thin film of liquid paraffin which adhered to the surface of the wound tissues. In order that a paste might be formed which would thus adhere to dehydrated tissues, he sought for suitable salts which would give stability. Since, despite the fact that laboratory examinations had for many years seemed to indicate that iodoform, *in vitro,* was devoid of bactericidal power, there had been a long tradition among surgeons to support the view that when introduced into wounds iodoform exhibited a definite property of at least inhibiting the growth of bacteria. Morison, therefore, decided to add iodoform to the paste in the form of powder. Since, moreover, Beck's paste, which consisted essentially of petroleum products and bismuth subnitrate, had been employed for a number of years in many clinics with, at least, somewhat gratifying results, and since it had proved its comparative harmlessness, he also introduced bismuth subnitrate.

B.I.P.P., as originally introduced by Morison, is, therefore, composed of bismuth subnitrate one part, iodoform powder two parts, and liquid paraffin about one part, or sufficient to make a thick paste. The authors of this paper wish to place themselves upon record as being of the opinion that Mori-

* Read before the American Surgical Association, White Sulphur Springs, W. Va., April 29, 1941.

son's preparation fulfills the aims suggested for it, and that attempts to modify it have been followed by relatively unfavorable results, particularly, it should be stated, as has been urged for many years,[2] that the essential nature of the paste is lost if soft paraffin (vaseline) be substituted for liquid paraffin since, if the former be used, a greasy ointment, which will not adhere to dehydrated surfaces, results.

Rutherford Morison's original employment of the paste, it should be borne in mind, was in the treatment of wounded soldiers who had gone through the various medical services in France, crossed the Channel, and been evacuated to the North of England; in other words, the cases, as he saw them, had already become infected and more or less serious grades of phlegmonous and suppurative inflammations initiated. Despite the above-mentioned unfavorable features of the cases as submitted to Rutherford Morison for treatment, the results obtained, and reported, by him were surprisingly satisfactory.

Gradually, during 1915, and particularly during the winter of 1915–1916, practically all surgeons working at Casualty Clearing Stations in the British Army had adopted the technic of wide incision and extensive excision of devitalized tissue, more particularly muscle, together with the extraction of foreign bodies. It had also been recognized that attempts at primary suture of such wounds could not be safely attempted unless it were possible to retain the patient at the Casualty Clearing Station for a period of at least one week. Since under battle conditions such a *desideratum* was absolutely impossible, the technic of packing wounds so that they would remain open was adopted by most Clearing Station surgeons. At that time Eusol* was the most popular adjuvant employed.

The introduction of Morison's technic and that of Carrel and Dakin were almost coincident in time and, as is well known, both stressed the importance of adequate enlargement and exploration of wounds, excision of devitalized tissue, and extraction of foreign bodies. Since practically all surgeons working at Clearing Stations, as mentioned above, had come to the conclusion that such procedures were not only desirable but imperative, no disagreement whatever arose regarding this aspect of the mechanical treatment of wounds.

It is not our purpose in this contribution to discuss Carrel-Dakin's method except to place on record our opinion that it is valuable, and that when circumstances are such that it can be carefully carried out the results are satisfactory. Under battle conditions, however, we are of the opinion that it is a method which, owing to the amount of attention required for each individual case, is not applicable.

During the spring of 1916, news of Rutherford Morison's method reached the Clearing Station surgeons and the technic was applied to "recent" wounds.†

* Edinburgh University solution.

† In this connection, attention should be drawn to the fact that it was unusual during the first phase of the war to see wounds at the C.C.S., which had been inflicted less than six hours prior to admission to the C.C.S., and that more often from eight to 15 hours or longer had elapsed.

There was an immediate recognition on the part of many Clearing Station surgeons[3] that in the liquid paraffin paste a great safeguard against serious infection had been contributed.

Unfortunately, as has been so often the case when new therapeutic procedures have been introduced, the technic was improperly employed, more especially in that too large surfaces were exposed to the action of the B.I.P.P. and too large quantities of the paste were left in the wounds. In consequence, there were in the British Army a small number of cases of iodoform, and more particularly bismuth, poisoning which in a few instances proved fatal. The mistake that was made in this regard was, we believe, chiefly in the introduction, following aspiration of hemothorax, of an emulsion of B.I.P.P. and liquid paraffin into the chest cavity. In this way, in a small number of cases, relatively enormous quantities of B.I.P.P. were introduced and brought in contact with very large absorptive surfaces.

The authors' opinion in this regard may be properly indicated at this point. Not more than one heaping dessert-spoonful of the paste should be left in the tissues; unless the area of raw tissue exposed to the paste exceeds 144 square inches, no important signs of poisoning need be feared. Fortunately, the exhibition of a blue-black line at the mucoperiosteal margin of the gums antedates, in all cases, by many days the development of important symptoms. The surgeon is, therefore, warned that caution must be exercised in further use of the paste.

For some reason, or collection of reasons which neither of us ever properly understood, by the late spring of 1918 the British surgeons working in France, more particularly those at the base hospitals, had divided themselves into two groups on the basis of their reaction to the employment of B.I.P.P. A small group, whose observation of cases had been unfavorable, were extremely vocative in their objections to its employment. The great majority of Clearing Station surgeons, and we believe also of surgeons working at the base, were, on the other hand, of the opinion that the wound that had been properly treated mechanically, dehydrated, and "bipped" reached the Base in better condition and with the wounded soldier more comfortable and in a fitter state than were those whose wounds had been treated in other ways. Unfortunately, however, those who saw fit to decry the method became so loud in their criticisms that the expressions of "belief in B.I.P.P.," or the contrary, were employed as though its use were based upon a religious credo. In consequence, the technic, which, in our opinion, is most easily carried out under battle conditions, as well as during less turbulent circumstances, is most satisfactory in its effects, and, if employed with reasonable care, is associated with less risk to the patient than other methods, fell into unwarranted disrepute in many quarters.

During the winter of 1917–1918, one of the authors (F. B. G.), while on a temporary transfer to England from France, undertook, at the request of Sir Robert Jones, a study of methods for the treatment of infected gunshot wounds of the long bones. The result of this study was published[4] in the

autumn of 1918. Various recognized methods of wound treatment were employed including the salt pack and acriflavine but more particularly Carrel-Dakin's technic and the employment of B.I.P.P. Insofar as we know, this contribution was the first occasion upon which the addition to Rutherford Morison's technic, of the employment of large liquid paraffin-soaked packs to which a small amount of B.I.P.P. had been added, was reported.

Although most surgeons have heard of B.I.P.P. and liquid paraffin packing, comparatively few, we believe, have thoroughly appreciated the essentials of the technic for its use. These may be tabulated as follows:

(1) The 4 E's—adequate enlargement; exploration and excision of devitalized tissue; and the extraction of foreign bodies, whether shell or bomb fragments, shrapnel balls, gravel, clothing, masonry or/and wood fragments.

(2) Dehydration by means of alcohol of the whole surface of the wound with subsequent removal of the alcohol in order that a dry surface may be obtained.

(3) Accurate and careful application of B.I.P.P. to the whole wound, with special reference to pockets and interstices, and the removal of all excess of the paste.

(4) If the wound be of such a character and the conditions under which interference is being carried out permit, the patient to be kept under observation for a period of at least seven days, primary suture may be advisable, although, in our opinion, little is to be gained by such a procedure and the risks usually contraindicate its employment.

(5) As a general rule, after the wound has been prepared, as for primary suture, it is carefully packed with soft gauze soaked in liquid paraffin to which a small amount of B.I.P.P. is added. Packing must be carried out in such a way that all interstices and pockets are obliterated by placing the gauze firmly into all the deeper parts of the wound. In this way "curtain" drainage is insured.

(6) In order to prevent retraction of the skin, and in order to insure the maintenance of distention by the packing of the deeper parts of the wound and so inhibit edema, it is often wise to place a small number of sutures through the skin, and in this way to more or less completely bury the packs.

(7) Adequate fixation and pressure must then be obtained. For this purpose either traction or plaster of paris must be used in the case of fractures or the employment of firm pressure bandages, or plaster of paris in the case of soft tissue wounds.

(8) Unless military exigencies render evacuation of the wounded soldier imperative, the patient should be watched, but the wound need not and should not be dressed for many (5 to 42) days.

(9) Indications for removal of dressings comprise pyrexia continued for longer than three or four days; other symptoms of toxemia; pain and proof of inadequacy of circulation. If plaster of paris has been employed, the temptation to make a window must be resisted. This point we[5] have urged for many years. The cutting of a window means decrease in pressure over

the area exposed; this, in turn, causes localized edema (interstitial tension), with consequent impairment of circulation, "water-logging" of the tissues about the wound and thus the production of these conditions under which pathogenic organisms flourish and tissue necrosis is accelerated.

During three years of the first phase of the war, the authors employed this method in many hundreds of cases. During the 23 years since 1918, we have relied upon the method as a sheet-anchor in assisting us to guide our contaminated and infected wound cases to a safe harbor. During the interval, we[5] have published our results in the treatment of compound fractures; in the control of infections of the hand;[6-8] and in the prevention of infection of the abdominal[9-12] or thoracic[13] wall when operating upon suppurative lesions within these body cavities.

Time does not permit even a résumé of these contributions. Suffice it to say that we are both of the opinion that were this ancillary method of wound —traumatic or operative—treatment not available we would nd the practice of surgery a much more embarrassing vocation.

In a paper upon "The Use of B.I.P.P. and Liquid Paraffin in the Treatment of Wounds," read before the American Association for the Surgery of Trauma at Atlantic City last year, and recently published,[14] we referred to the fact that small amounts of nitric acid are gradually liberated in the "bipped" wound, and that iodine may be recovered from the urine for as long as three weeks after the introduction of the paste.[15] The essential differences between the method which is the subject of this contribution and the so-called Orr method is also referred to. Suffice it to say, in this regard, that we believe that the substitution of soft paraffin (vaseline) for liquid paraffin, and that of bismuth and iodoform, by a disagreeable odor, are not in themselves of sufficient importance or value to justify the claim of originality which has been made.

As a means of presenting the technical procedures and the results which may be expected we present, herewith, brief descriptions of illustrative cases. For this purpose, cases which represent three typical categories are outlined:

(1) A suppurating phlegmonous lesion of the hand.
(2) A lacerated contaminated wound of the leg—complicated by massive gas gangrene.
(3) A case of pulmonary abscess in which protection of the chest wall prior to evacuation of abscess was accomplished.

ILLUSTRATIVE CASE REPORTS

Case 1.—A boy, age nine, was admitted, January 9, 1941, with a severe suppurative lesion of the left hand involving the muscles of the thenar space. The infection followed a comparatively trivial scratch nine days previously. He was operated (L. H. McK.) upon under cyclopropane anesthesia. The cuff of the blood pressure apparatus was used to secure a bloodless field. After wide incision, a large quantity of necrotic material was wiped out, the cavity was dehydrated with alcohol, treated with B.I.P.P., and packed with liquid paraffined gauze. Cultures from the wound showed *Staphylococcus aureus*. A biopsy was taken from the skin edge. After recovery from anesthesia,

there was relative absence of pain. Five days later the wound was dressed under anesthesia and a second biopsy taken. At this time, the wound was covered with healthy granulations. There was no edema of the skin about the wound or elsewhere in the hand. The wound was dressed with sterile liquid paraffin on gauze dressings. Subsequent dressings were performed at four- to six-day intervals. In spite of the large area of destruction of skin, subcutaneous tissue, and muscle, healing was complete in slightly over three weeks.

FIG. 1. FIG. 2.

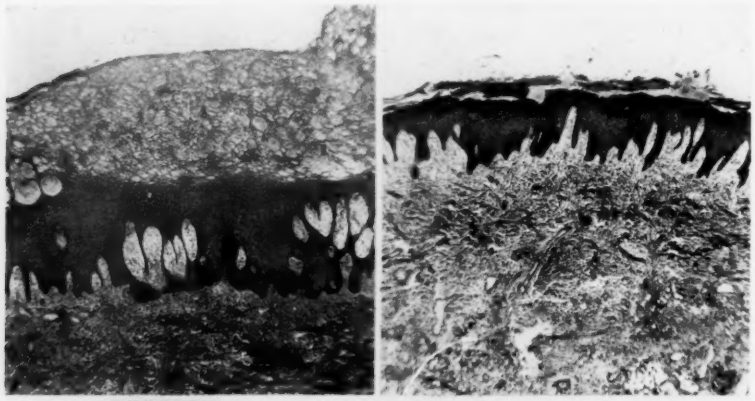

FIG. 3.

FIG. 1.—Case 1: C. H. This photograph taken at the time of the first dressing, five days after packing, shows the typical characteristics of infected wounds treated by this method. The granulations are uniform and of a distinctive color. There is an entire absence of edema. This latter characteristic is even more graphically shown in the photomicrographs.

FIG. 2.—Case 1: C. H. Microscopic section of biopsy from the edge of the wound. January 14, 1941, at the time of incision and liquid paraffin packing. Note marked edema in the superficial layers of epithelium and moderate edema of the corium.

FIG. 3.—Case 1: C. H. Microscopic appearance five days after incision and B.I.P.P. paraffin gauze packing. Note almost complete absence of edema of epithelium and subepithelial structures.

The second group is illustrated by a severe wound of the leg complicated by the development of gas gangrene.

Case 2.—L. Corpl. V. R., age 26, a dispatch rider in the C.A.S.F., suffered a motorcycle accident January 13, 1941. He received a lacerated wound which occupied the middle third of the anterior border of the left leg, which tore through the interosseous

membrane and was complicated by a fracture in the middle third of the fibula. He was immediately admitted to the military hospital in the neighborhood where débridement of the wound was carried out and the latter closed in layers: a continuous catgut suture to the sheath overlying the tibialis muscle and a continuous silk suture to the skin. Antigangrene and antitetanic serum were administered.

FIG. 4.

FIG. 5.

FIG. 4.—Case 2: V. R., January 16. Posteromedial aspect of the leg. The line drawn on the skin shows the upper limits of tympanites; up to this point from the neighborhood of the ankle the note which could be elicited was drum-like.

FIG. 5.—Case 2: V. R., January 16. Posteromedial aspect of the leg after incision through skin, gastrocnemius and soleus muscles and after tearing out the gangrenous tibialis posticus muscle. The amount of B.I.P.P. which may be rubbed on with impunity is illustrated.

Rather suddenly, on the evening of January 15, he became very ill, as indicated by elevation of temperature, rapid pulse, apprehension, and severe pain in the limb. He was then shipped by ambulance to the Montreal General Hospital during the night, January 15–16. The sutures in the skin and in the fascia were immediately removed by the resident-in-charge, and he was given a further dose of antigangrene serum (40,000 units) and sulfanilamide, which had been employed in the military hospital from the time of his injury was continued and increased in amount.

When seen (F. B. G.) during the morning of January 16, he looked toxic, pulse 140, and complained of severe pain in the left leg below the knee. Examination of the leg showed a wound occupying rather more than the middle third of the anterior surface of the leg, which was of the typical color associated with gas gangrene and from which a small amount of anchovy sauce-like pus together with gas bubbles was being exuded. Examination of the limb, by both percussion and "flicking," showed the anterior part of

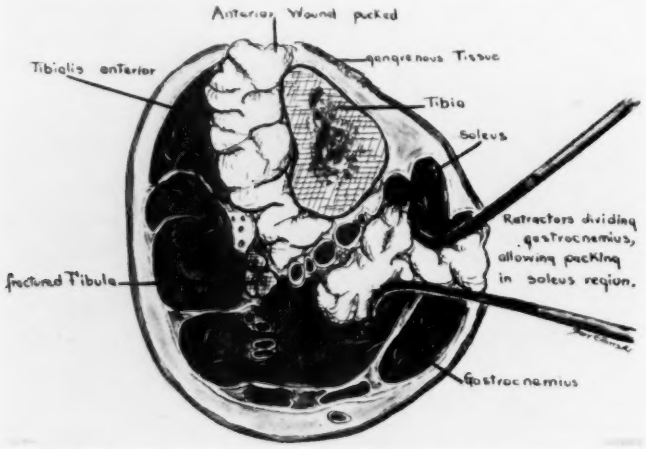

FIG. 6.—Case 2: V. R. Diagram to illustrate manner of inserting liquid paraffin-soaked "bipped" gauze packs. Note such packs must be firmly pressed into position; especially must all interstices be distended.

the leg, except for the immediate neighborhood of the wound, to be free from gas. The calf, however, was tympanitic and drum-like to percussion from the ankle joint up to the posterior border of the knee joint. The skin over the calf was definitely discolored brownish-yellow. Smears made from exudate from the open wound on the anterior border of the limb showed large gram-positive bacilli—*Cl. welchii—perfringens.*

It was clear, therefore, that the soldier was suffering from massive gas gangrene of the leg. Operation was carried out in the early afternoon of January 16. Under cyclopropane anesthesia, the skin and fascia over the anterior tibial group of muscles were incised from the ankle joint to the knee. Over the middle third of the leg, a mass of the tibialis anticus muscle was found to be downy, purplish-brick red in color, and manifestly dead. This mass of muscle (approximately the middle third) was excised. It was evident that the instrument responsible for the wound had, in addition to fracturing the fibula which, however, was not involved in the compounding, torn the periosteum off the lateral border of the tibia over the middle third of the bone and had then penetrated the interosseous membrane and damaged the posterior tibial group of muscles.

On the posteromedial aspect of the calf, an incision from the ankle to the knee was made through skin, subcutaneous fascia, gastrocnemius and soleus muscles throughout the whole length of the incision. Both of these muscles were normal. The tibialis posticus and at least part of the flexor longus digitorum were evidently the site of massive gas gangrene. Since past experience in France, during the first stage of the war, had proven that dissection of the tibialis posticus could hardly be carried out without damage to the neurovascular bundle, the gangrenous muscles were torn out by the fingers. In this way it appeared as though all of the tibialis posticus and most of the flexor longus digitorum were removed.

A number of Kelly clamps had been applied up to this stage to control bleeding vessels; since, however, no large vessels had been damaged it was deemed advisable to

avoid ligatures. Both wounds were sloshed with alcohol in order to dehydrate the surface tissues and B.I.P.P. carefully rubbed into all interstices and superficial parts. Four-inch soft gauze soaked in liquid paraffin and to which a small amount of B.I.P.P. was added was firmly packed into the depths of both the anterior and posterior wounds; the surfaces of both wounds were similarly covered with liquid paraffin-soaked gauze.

To secure moderate fixation, and more particularly in order that edema might be prevented, the limb from the middle of the thigh to the toes was surrounded with a thick layer of absorbent cotton which was fixed in position by a circular gauze bandage, using as much pressure as the bandage would stand.

FIG. 7.

FIG. 8.

FIG. 7.—Case 2: V. R., January 29. Posteromedial wound after superficial pack has been removed. This picture shows surface of the deeply placed pack in position. Note the absence of edema, the almost complete absence of hemorrhage and the absence of suppuration.

FIG. 8.—Case 2: V. R., March 20. Lateral aspect of the leg showing foot in plantar flexion, upper and lower thirds of wound closed by secondary suture. Middle third of wound is sound and ready for skin graft.

Sulfanilamide was continued and antigas gangrene serum until 200,000 units had been administered by both the intravenous and muscular routes. Since roentgenotherapy, as recommended by Kelly,[14] is thought to be at least harmless, and since this soldier's condition was judged to be critical, this procedure was employed.

The patient's postoperative condition remained absolutely satisfactory. The pulse rate dropped as well as the temperature, and his feeling of well-being was restored. The limb was not dressed until January 23 when, under an anesthetic, the dressings were removed, as well as the packs on the anterior surface and the more superficial packs on

the posterior wound. Except for an area of skin gangrene medial to the anterior wound and at the site of the original trauma beneath which a small amount of superficial suppuration was noted, absolutely no exudate and no necrosis was noted anywhere within the limb.

The third dressing was carried out February 6, when it was noted that the gangrenous area in the skin was commencing to separate and that the inflammatory focus beneath it, which had been firmly packed January 29, had cleared up. All packs were removed, including the deep one on the posterior border which had been inserted two

FIG. 9.—Case 2: V. R., March 20. Medial aspect of the leg showing foot in dorsiflexion. The success of secondary suture of posterior wound is demonstrated.

weeks before, and both wounds were repacked using approximately one-third of the amount of packing which had originally been employed.

On February 13, it seemed evident when a fourth dressing under an anesthetic was done, that secondary suture of the posterior wound was possible; this was accordingly carried out. Silkworm gut sutures through skin and subcutaneous fascia, and which took bites through the fascia covering the gastrocnemius, were inserted following dehydration and careful "bipping" of the whole wound. The gangrenous skin on the anterior border had now separated and the wound was clean. However, owing to the fact that such a large area of tibia was bared of periosteum and since it was not possible to close the anterior wound without some form of skin graft or plastic procedure, it was deemed advisable to repack this wound and postpone an attempt at closure.

On February 22, dressing was carried out in the ward without an anesthetic, the posterior wound was found to have healed practically *per primam*, and the anterior wound to be absolutely free from suppuration. Alternate sutures were removed; remainder removed five days later.*

By March 20, it appeared that the whole of the bared lateral border of the tibia had been covered by granulations and that the danger of superficial exfoliation of the bone had been averted; consequently the middle third of the anterior wound was covered with Riverdin-Davis grafts. The upper and lower thirds had previously been successfully closed by secondary suture. Approximately 75 per cent of these grafts "took" and the remainder of the wound progressed rapidly to complete healing.

* It should be noted that when a wound is "bipped" and sutured, it is advisable to allow sutures to remain in place for approximately double the usual length of time for the individual part of the body concerned.

The patient was out of bed walking, without a limp, April 2, and was discharged from hospital April 14. At the time of discharge, foot, ankle, and knee movements were normal and the sural muscles exhibited a substantially normal strength.

The accompanying illustrations present photomicrographs of specimens removed (1) at original operation January 16; (2) at dressing January 29, and (3) at operation

FIG. 10. FIG. 11.

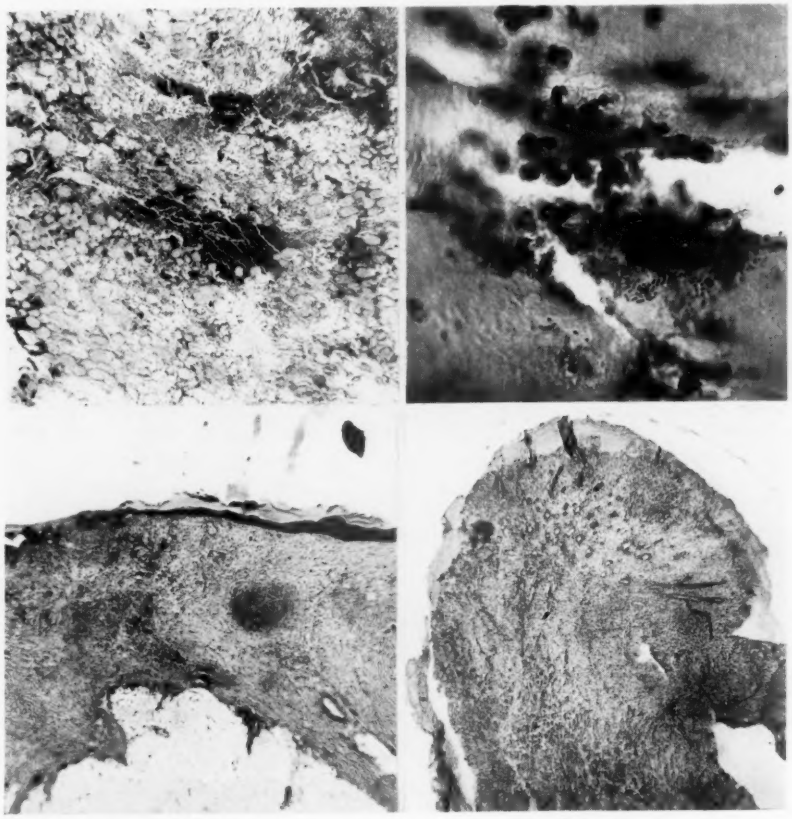

FIG. 12. FIG. 13.

FIG. 10.—Case 2: V. R. Microscopic picture, January 16, representing a portion of the tibialis anticus muscle. Note the presence of dead muscle fibrils, gas bubbles and infiltration with inflammatory cells.

FIG. 11.—Case 2: V. R., January 16. Oil immersion microscopic picture of portion of excised muscle. Note the presence of dead muscle fibrils separated by gas bubbles, infiltration of polymorphonuclear leukocytes and large numbers of *Cl. welchii* (perfringens).

FIG. 12.—Case 2: V. R. Biopsy of wound edge. January 20. Note commencing growth of epithelium, almost complete absence of edema and relatively small number of inflammatory cells.

FIG. 13.—Case 2: V. R., February 13. Microscopic picture of portion of tibialis anticus muscle. Note comparatively thin layer of scar tissue the deeper layers of which have progressed to fibrosis and the overlying granulation tissue free from edema and exhibiting adequate fibroblastic proliferation.

February 10. The legends beneath the photographs indicate the features that they illustrate; in particular, we wish to stress the absence of edema and the thin firm fibroblastic characteristics of the granulation tissue.

In earlier contributions we have described, in some detail, the method employed to protect the abdominal wall from contamination by infection when

operating upon intra-abdominal abscess of appendiceal or other origin. A similar technic has been used for many years by our colleague, B. F. MacNaughton of the Department of Laryngology, in operations upon the mastoid and similar procedures. In the performance of thoracotomy for empyema and in the more extensive procedure used in the treatment of pulmonary abscess, we have employed a similar technic. The following case history illustrates the method used for the latter purpose.

During recent years, one of us (F. B. G.) has developed and employed a technic for the treatment of pulmonary abscess which consists essentially in the turning back of a large flap in the chest wall overlying the abscess and the removal of substantial lengths of three ribs. The essential feature of this technic, which it is desired to point out at this time, is the method adopted at the first stage of the operation in order to prevent infection of the chest wall when the infected lung is opened at the second stage. This aspect of the method is illustrated by procedures adopted in the following case:

FIG. 14.—Case 3: R. B. Photograph of wound 11 days after it was fashioned. The absence of edema is shown.

Case 3. The patient was a boy, age 15, in May, 1940. There was present a large upper lobe apical abscess from which eight to ten ounces of foul sputum was being expectorated daily. Under spinal anesthesia, a skin and subcutaneous tissue-flap was turned back over the anterior surface of the upper part of the chest, about 12 cm. in width and about 15 cm. in length. Both pectoral muscles were displaced inward and upward, and the second, third and fourth ribs were removed from the cartilage to the posterior axillary line. The intercostal bundles were detached anteriorly and turned back.

After hemostasis had been secured, the whole wound was dehydrated with alcohol and carefully "bipped," with special reference to all pockets beneath and between the muscles. The whole wound down to the parietal pleura was then tightly packed with a large four-inch liquid paraffin-soaked "bipped" gauze pack and the skin-flap sutured back in position.

Eleven days later sutures were removed and the packs taken out. Absolutely all parts of the wound were covered with firm, bright red granulations which did not bleed. The parietal pleura and the surface of the lung overlying the abscess were then removed and the gangrenous abscess opened. The further course of events is not germane to the present discussion. Suffice it to say that approximately five weeks from the date of the first stage of the operation he was discharged free from cough, free from sputum, and had gained 12 pounds in weight.

To sum up, the advantages claimed for B.I.P.P. and liquid paraffin treatment are:

(1) Relief of pain.
(2) Stimulation of a healthy reaction on the part of the tissues and control of original infection.
(3) Infrequent dressings with consequent:
    (a) Avoidance of secondary infection.
    (b) Avoidance of pain.
    (c) Conservation of time of both surgeons and nursing sisters.
(4) Adequate fixation by either traction or plaster of paris.
(5) Economy of dressings.

One of the most important features of the technic recommended in this contribution is the fact that dressings need not be carried out except at long intervals. Although, in the case of minor wounds, it may be deemed advisable to interfere after a relatively short interval—three to five days—in order that delayed primary suture may be undertaken, and although, in some unusually contaminated or infected wounds, it may be thought necessary to examine the wound after a relatively short interval, there is, under normal conditions, no necessity for a change of dressing in less than three to six weeks. Of importance, too, in this regard is the fact that such wounds do not smell badly.

Finally, the employment of the B.I.P.P.-liquid paraffin technic is specifically recommended for the following purposes:

(1) Acute traumatic lesions whether due to gunshot wounds, automobile injuries, or construction accidents associated with potential infection and with particular reference to compound fractures. In the less severe types of wounds of this sort, we may occasionally undertake a complete primary closure. We believe, however, that a delayed primary closure is nearly always advisable. This adds a considerable factor of safety and very little time is lost. When the loss of tissue has been great, so that delayed primary suture is impossible or when there is moderate infection, we employ secondary suture or make use of various plastic procedures for filling the defects.

(2) Infected wounds may be the result of untreated trauma or suppurating or phlegmonous wounds from other causes.

(3) As a prophylactic measure against the infection of the body wall in the opening of certain infected cavities. Notably: (a) Abdominal abscesses—appendiceal or otherwise; (b) empyema or lung abscesses; (c) operations on the mastoid or other deep-seated abscesses.

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IDEAL ORGANIZATION FOR CATASTROPHE SQUAD

THE Bellevue Catastrophe Squad is taken as a model, and the Medical Preparedness Committee hopes that all communities will organize such Squads along the same lines and notify it of such organization.

Organization.—The Squad consists of a group of 12 graduate nurses plus a nurse as Captain, and 12 interns plus an intern as Captain. Thus, each Squad consists of 26 members.

Ambulances.—One emergency ambulance and an ambulance-bus. The emergency ambulance serves to transport those who need hospitalization from the scene of disaster to the hospital. The large bus (ambulance), seating 26 persons, also carries all equipment.

Equipment and Supplies.—(a) Two large wooden boxes (3′ x 2′ x 2′), each containing drums with sterile supplies and medications (instruments, gauze, bandages, narcotics, iodine, alcohol, *etc.*). (b) One large wooden box (3′ x 2′ x 2′), with all sorts of splints and bandages necessary for the treatment of fractures. (c) A small box containing many syringes and T.A.T. vials. (d) Two canvas bags containing blankets, which are spread on the ground and upon which pateints are treated.

Duties.—As a rule, nurses and doctors group themselves into teams of two, *etc.*

The Captains supervise the work of the Squad.

The nurse in charge of the Emergency Ward has the responsibility of seeing that all boxes are adequately supplied and ready for immediate use. Everything is checked upon return from a call. In any event, all material is resterilized once every month.

General.—The Squad responds to any major disaster occurring anywhere in the locality of its establishment. All calls for the Catastrophe Squad come to it from the local police headquarters.

COL. SAMUEL J. KOPETZKY, M.D., *Chairman*
Committee on Medical Preparedness

—N. Y. State Journal of Medicine.

EMERGENCY TREATMENT OF WAR INJURIES OF THE FACE AND JAWS *

ROBERT H. IVY, M.D., U. S. ARMY

AND

ROY A. STOUT, LIEUT. COL., DENTAL CORPS

TORONTO, CAN.

EXPERIENCE with injuries of the face and jaws gained during the last war and with cases subsequently seen in civilian and military practice teaches us that provision should be made for adequate specialist care as early as possible. A correlated plan of treatment, if carried out from the advanced zone to the installations in the rear, will greatly shorten the period of disability and a larger number of these casualties will be restored to approximately normal function and appearance than if haphazard methods are followed. Preparations have already been made in the office of the surgeon general for a systematic plan of treatment of these cases in wartime. Instructions are being prepared for the handling of jaw injuries by medical department units from the combat zone back to the general hospital so that a uniform plan will be followed. Special training is being given to medical and dental officers and enlisted men of the medical department who will be assigned to units from the combat zone to the general hospitals.

The most efficient treatment of face and jaw injuries entails close cooperation between officers of the medical and dental corps. The general care of the patient, the problems of wound infection, and tissue repair will be largely in the hands of the medical officer, while the special problems of fixation of jaw fractures and care of the mouth and teeth lie within the field of the dental officer. These two parts are not to be carried out separately, however. Each branch must have an understanding of what the other involves, so that the treatment will be merged into a homogeneous entity.

In meeting the emergency, it is expected that courses of instruction will be given to medical and dental officers who have been selected as specialists in this particular field. A manual is now being prepared, covering the various phases and problems of treatment of face and jaw injuries from first aid to final reconstruction.

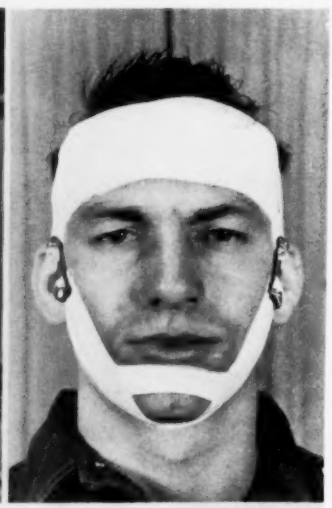
The most advanced organization to which it is contemplated that specialists in the care of face and jaw injuries will be attached, is the surgical hospital, a mobile unit, operated in connection with the clearing station, located seven to ten miles to the rear of the front line. (It is realized of course that modern mobile warfare may entirely disrupt tables of organization planned on paper. Yet, for purposes of assignment of personnel and equipment, such

* Read at the Meeting of the American Surgical Association, White Sulphur Springs, W. Va., April 29, 1941.

plans are necessary.) Each surgical hospital, according to the plans, will have a maxillofacial team, consisting of a surgeon and a dental surgeon, trained in the special requirements of treatment of these injuries. Before reaching the clearing station and the surgical hospital, however, the wounded man may receive emergency care from the company aid men and the battalion aid station, to which no specialists are attached, but where the enlisted men and the battalion medical and dental officers have received certain instructions in the use of emergency equipment with which they are provided.

FIG. 1.

FIG. 2.



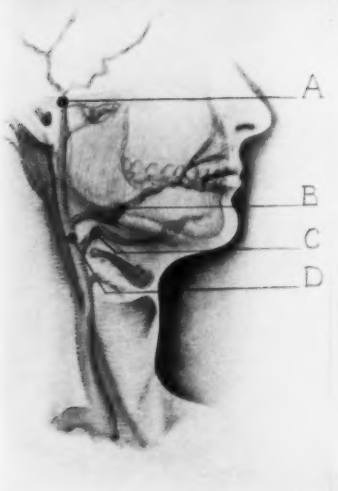


FIG. 3.

FIG. 4.

FIG. 1.—Four-tailed bandage adapted from first-aid packet.
FIG. 2.—Elastic traction by rubber bands and safety pins.
FIG. 3.—Point of compression for temporary arrest of hemorrhage.
FIG. 4.—Tongue held forward by transfixion of tip with safety pin.

There are some things that can be done and others that should not be done at these advanced posts by the medical personnel which will probably save many lives and facilitate the later treatment of face and jaw wounds by the specialists.

Every officer and soldier of the medical department in the combat zone is supplied with equipment useful in rendering first-aid treatment for jaw injuries. The first-aid packet adapts itself admirably for jaw fractures and can be applied suitably to a great many types of gunshot wounds of the face and head. The compress, sewn to the central portion, can be made to serve as a hammock or sling to support the injured structures. By tearing the attached bandage lengthwise, the dressing becomes an ideal four-tailed bandage which may be securely and satisfactorily applied by officer or enlisted man (Fig. 1). The compress itself can be separated from the bandage and used as an extra packing, dressing, or support over any region as may be necessary. The safety pins in the first-aid packet assist in making the dressing secure. With the aid of common rubber bands or elastics and the safety pins, emergency fixation can be applied (Fig. 2) and anchorage secured to the "overseas" cap.

The points demanding special attention in the combat area may be formulated as follows:

(1) Arrest of hemorrhage.
(2) Provision of adequate respiratory airway.
(3) Temporary approximate reduction and fixation of bone fragments.
(4) Provision of safe transportation from the combat zone to hospital in the rear.

(1) *Arrest of Hemorrhage.*—It may be possible to check hemorrhage temporarily by digital pressure over an artery proximal to the bleeding area. The principal points of compression about the head and neck are: External carotid artery—beneath anterior border of sternomastoid muscle just above level of thyroid cartilage; facial or external maxillary artery—lower border of mandible ¾ inch in front of angle; superficial temporal artery—just in front of tragus of ear (Fig. 3). Moderate hemorrhage from a wound about the jaw can usually be checked by pressure from a gauze pack inserted in the wound and held in place by a four-tailed bandage. Care must be exercised in the application of the pack and the bandage so as not to increase any respiratory difficulty occasioned by the nature of the wound itself. Hemorrhage that cannot be checked in this way demands a search for the bleeding vessel and application of a clamp to it, followed by ligation, if ligature material is available; otherwise, the clamp should be left on during transportation to the advanced hospital.

(2) *Provision of Adequate Respiratory Airway.*—Loss of bone and muscle attachment frequently results in loss of control of the tongue with danger to

respiration. This is best controlled by use of a long suture through the tip of the tongue. It should be long enough to draw the tongue forward and may be attached to the dressing or clothing. If a needle and suture are not available, the tip of the tongue may be transfixed with a large safety pin (Fig. 4). A piece of gauze or bandage may be attached to the tongue suture or safety pin for traction to improve and clear the air passage. These considerations are particularly important, if the patient is unconscious. In other cases, due to swelling of the soft tissues, sufficient airway can be provided by insertion of a rubber tube through the nose or the mouth to the nasopharynx. If these means are not adequate, tracheal puncture through the skin with a special trocar will usually save the situation. It is expected that these tracheal trocars will be added to the emergency kit. Tracheotomy should only be considered as a last resort, since it is followed by a high mortality in cases of this type.

(3) *Temporary Approximate Reduction and Fixation of Bone Fragments.*—If a dental surgeon is available, he should be assigned the problem of temporary fixation. Each dental surgeon at advanced stations is provided with an emergency maxillofacial kit, which contains instruments and materials for emergency dental operations and for application of temporary fixation of fractures of the jaws. Intelligent application of emergency treatment reduces the period of hospitalization and assures far greater success in subsequent treatment with a minimum of deformity. Early treatment should be such as to assure every chance for the restoration of original occlusion of the teeth, or the retoration of the function of mastication, even in those cases with considerable loss of bone. It is particularly important that the collapse of bone segments be avoided. In order to minimize infection, early cleaning up of the wound is essential, and tooth fragments, foreign matter, completely detached particles of bone, *etc.*, should be removed. Often overenthusiastic débridement is instituted and bone fragments which still possess periosteal attachment are taken away. Bone fragments which have any attachment to the soft tissues should be allowed to remain, as they frequently keep their vitality and aid in restoring continuity of bone. It is much wiser to leave a bone fragment of doubtful vitality, removing it later in case of necrosis, than to perform a radical removal of all loose pieces of bone, with resulting defects that require grafting later. Reduction of fragments by manipulation and temporary fixation by simple measures, such as bandages and elastic traction, should be done if possible at this time. Wiring of teeth of the same jaw across the line of fracture may be used in some cases to maintain fragments during evacuation to the rear, but fixation of the lower to the upper teeth should never be used prior to unattended travel. Fixation is important at this stage, for stabilization of the fragments helps to reduce pain and shock. It also assists in the control of the tissues essential for the maintenance of a clear air passage, and reduces the danger of recurrent hemorrhage. Military conditions may permit the application of some of these fixation

measures by the dental officer at the battalion aid station. If not, they must be deferred until the wounded man reaches the surgical hospital, or the evacuation hospital.

Fractures of the superior maxilla frequently displace the loose structures downward and backward and definitely interfere with respiration. In case of a bilateral comminuted fracture of the posteri part of the mandible, the anterior part of the jaw may drop backward and likewise cause serious interference with respiration. In a case of this kind, the front of the jaw may be held forward by a simple emergency splint developed at the Walter Reed General Hospital and found practical in several cases. The only articles required are three or four wooden tongue depressors, adhesive plaster, a two-inch bandage, and the ligature wire supplied with the emergency maxillofacial kit. Two tongue depressors are placed end-to-end and fastened by a third overlapping them in the middle with adhesive plaster. This piece is secured in a vertical position with a bandage passed around the head in the frontal region, with the lower end extending in front of the chin. A wire is passed around the lower front teeth or around the chin segment of the mandible and the ends of the wire fastened to the lower end of the tongue depressor piece. The spring of this will effectively draw and keep the anterior segment of the mandible forward. In the case of backward displacement of the upper jaw, forward traction can likewise be made by attachment of the upper front teeth to this apparatus (Fig. 5).

FIG. 5.—Forward traction of either upper or lower jaw by emergency apparatus made from tongue depressors and bandage.

In jaw fractures, complicated by large gaping wounds of the soft tissues of the face, one may be inclined to attempt closure of the soft tissues by early suture. Where there is soft tissue loss, this should never be done before at least temporary reduction and fixation of bone fragments, otherwise collapse of the latter will occur, with great deformity and interference with function. Exposed bone should be covered by soft tissue whenever possible, in this way infection being reduced to a minimum. In large gaping wounds, communicating with the mouth, it is advisable to suture skin to mucous membrane over exposed bone ends. This shortens the time of healing and permits earlier institution of permanent reparative procedures. No wound in the

region of the lower jaw communicating with the mouth or with the bone should be closed without provision for dependent drainage.

(4) *Provision of Safe Transportation from the Combat Zone to Hospitals in the Rear.*—Transportation or evacuation from the combat zone places a certain responsibility on the medical department units, for casualties must be prepared for safe, unattended travel by ambulance or hospital train to general

FIG. 6.—Face-down position on litter with forehead resting on strap to maintain adequate airway during transportation, in serious jaw injury.

hospitals. Aside from problems of nourishment, sedation, and prevention of shock special considerations apply to face and jaw injuries. Lessons in past wars are convincing proof that ambulant or semiambulant cases with oral or pharyngeal wounds should sit up during evacuation. If he must be recumbent, the patient should be placed face down if there is any danger of obstruction in the air passages. These precautions lessen the mortality rate of jaw injuries during evacuation (Fig. 6).

The time required for the wounded to reach the general hospital, which may be situated 100 miles or more to the rear of the front line, varies considerably. But the desirability of safe, rapid evacuation to the place where definitive treatment can be given is obvious. The measures outlined above, if carried out properly, will insure the arrival at the base of a large percentage of cases of jaw injury in good condition for definitive treatment. In the general hospitals, every possible facility is provided in the way of equipment and special personnel for the proper care of these cases. The nature of the treatment required here depends to a large extent upon the kind of preliminary care that has been given in the more advanced zone.

DISCUSSION.—LIEUT. COL. ROY A. STOUT (Dental Corps, United States Army): (Slide) First, I want to show you a few pictures of the war injuries that involve the face, particularly the overlying soft tissue and the bones of the upper jaw and the mandible. These pictures were taken from the World War and show just the marked loss of bone and loss of overlying soft structures.

(Slide) This is the outside of the same case, showing the loss of part of the mandible and the soft tissue along with it. Colonel Ivy mentioned the possibility of suturing the skin and mucous membrane over the bone ends.

(Slide) Another injury of this sort, with involvement of the upper lip and marked comminution of the bone of the synthesis, where the tissue perhaps was—an effort was made to suture the skin together.

(Slide) Showing some collapse of the bone fragments, the lateral segments of the mandible (slide) with the result of almost complete loss of the anterior portion of the

mandible, making very difficult repair and restoration of a man of this character to society.

(Slide) In this instance, there is loss of bony substance of the upper jaw, and perhaps in the early stages, with collapse of and interference with the air passages; this type of injury might be helped by some form of anterior traction, as we will show later.

(Slide) With the loss of the anterior portion of the mandible and the tongue being freed so that it is allowed to fall back in the throat and interfere with the air passages. As Coloney Ivy mentioned, this type of case should be transported, certainly, face down, and perhaps the tongue transfixed with a suture or, as a first-aid package, equipped with a safety pin to hold the tongue forward, or to suture it to a dressing might be applied in emergency to advantage.

(Slide) This chart shows the points of compression for digital pressure, where hemorrhage might be controlled in an effort to save life, and where instruction is given to people to use digital pressure for the external carotid.

(Slide) This shows a picture of the tongue having been transfixed with a safety pin. It was a drawing to indicate the attachment that could be made to an external appliance or to a dressing, as we see in the next ; icture.

(Slide) This does not show too well, but the suture is placed through the tongue and attached to the dressing, and there is a rather heavy supporting bandage to help hold the fragments in their proper relation.

(Slide) The first-aid packet is equipped with a bandage that has a compress in the center of it; as a matter of fact, it is sewed to it. The extension on the bandage can be torn or cut and applied as a support for the mandible, or used as a compress in the wound in the anterior part of the mandible to control hemorrhage. It can either be applied in this manner and the two tails tied over the skull or, in the next picture (slide), it can be lowered and tied back to the neck and then connected.

(Slide) This type of bandage is a modification of the Gibson bandage, showing that the bandage can be cut, safety pins placed at either end, and elastics put around where elastic traction is desired. Rather than fixing the bandage definitely, offering the elastic traction gives the patient more comfort and permits him to open his mouth in emergency. If the mandible is not fractured and there is injury to the maxilla, very often occlusion of the teeth can be so arranged that elastic bands will give you support to the maxilla.

(Slide) In the transportation of a man not so seriously injured, he might be placed on his side, if he is too sick to sit up. Transporting him in a sitting position, of course, is better, but certainly he should not be placed on his back with his head high if he has a soft tissue or tongue injury, or an injury that might interfere with the airway.

(Slide) This position, with the face down, is much preferred. In the more serious cases (slide), the man may take advantage of the strap that is on the litter, or a bandage might be put around to further support his head and allow the mouth, *etc.*, to be over an open space so that drilling would not interfere with the respiration.

(Slide) For the wiring of fractures, within the same arch or in both arches, this type of wiring has been found very satisfactory. These loops are formed of one wire that is on the buccal aspect of the teeth; it binds three or four or more teeth together, gives anchorage with a broad case and allows the elastics to be applied over the loops for intermaxillary elastic traction. We try to avoid fixed intermaxillary relations. It is certainly so at the front. Even farther back, the elastic traction, we find, supports the good mandible, and the maxilla also in relation to the mandible, with less discomfort to the patient.

Triangular ligatures can be applied, or in some instances diagonal ligatures.

(Slide) This is another similar case with the application of an additional wire over a line of traction, the parallel elastic traction, the diagonal elastic traction here coming from the anterior part of it distally and the distal part forward.

(Slide) Where there are a number of missing teeth, wire can be twisted across that space, and carried over to this space. A space for about three or four teeth may be bridged by wire in this manner and may save the application of an arch. It is very simple to apply, leaving one wire in the application of these wires; and the fixation is adequate.

(Slide) This is a gunshot wound. One of our officers apprehended a prisoner and was shot with a 45. A bullet entered the angle of the mouth in that region and caught the mandible at the first molar. The fracture line comes down around underneath these

teeth with marked comminution of the mandible throughout the angle and almost the entire ramus. This man had very excellent first-aid treatment, and had a result with a loss of only one tooth. The elastic traction was used on arch bars, and eventually he was sent in to Walter Reed Hospital for final treatment.

(Slide) This shows the same case with this sequestration having been removed and all the possible vital bone fragments saved, and with the consolidation of the fracture around the first molar. I might say that this case functioned very well. He has good function, and the suppuration has entirely ceased. It will be necessary, no doubt, to do bone grafts later.

(Slide) This shows the same case, anterior-posterior view, with loss of substance in that part.

(Slide) Before anterior traction, and in order to simplify, we have made an appliance with two coat hangers, one in the upper half and one in the lower half, and a third coat hanger goes around to stabilize it in the middle. This portion here is removable and can be unhooked. It is simply attached to a bandage wound around the head, and with the cranial anchorage, external traction may be applied with elastics. It is surprising, the amount of traction we can put on this sort of appliance.

(Slide) This picture should have come a little later. Anyway, this is the one showing external traction with the tongue blades. Any other support could be used instead of tongue blades, but they are usually available, and two tongue blades are placed over the end wound with adhesive tape.

(Slide) This shows a side view of it, with the amount of spring that can be obtained. Adhesive tapes are placed at the top to the posterior part of the bandage, and a reasonable amount of traction can be gotten for the upper jaw or the lower jaw or the mandible, or any of the soft tissues. This can be cut off at this point and rotated for the malar bone or soft tissues of the nose. It is very useful for any anterior traction where the force does not have to be excessive.

(Slide) This shows the coat hanger arrangement. This particular patient had a fracture of the maxilla bilateral and also fractures of the neck of the condyloid processes on both sides and with marked displacement of the maxilla distally over 1 cm. Later we were able to close by application of the wire loops and the attachment. With rubber ligatures, we were able to pull the maxilla forward and occlude with the teeth of the lower jaw and establish formal occlusal relation.

(Slide) This shows that same appliance and how quickly it is removable for the patient's comfort. The elastic is unhooked, and this tie underneath the mandible is unhooked, and can be turned off and removed, with a great deal of comfort for the patient.

(Slide) This is the same appliance, showing the bandage used around it and the external traction.

(Slide) This man had an airplane accident, and the upper jaw was forced back, also over 1 cm., and by external traction five weeks later, we were able to pull forward to establish the normal occlusion of the teeth.

I would like to take this opportunity to thank Colonel Ivy for being able to participate with him in the presentation of this paper. It is a pleasure to be here, and I thank you.

Dr. James Barrett Brown (St. Louis, Mo.): I have had the sum total of experience of being detailed orderly duty in a ward full of influenza in the last war, so I cannot be very authoritative on any war injuries; but we have seen a lot of injuries since the last war, and I think the traffic accidents and the gunshot wounds you see in civil life may approximate those you perhaps will see in the Army.

There are just a few points I might mention. I heartily agree that the early care of these injuries is important, of course, acquiescing to the condition of neurologic examination or bad general shock until those features are controlled.

It is impossible to separate jaw fractures and soft tissue injuries, because they occur so commonly together. They both have to be considered, and certainly the bone part should not be thrown away, and certainly no radical débridement should be done by cutting matter off the soft spots. They should be cleaned very carefully, but no spots cut out, because it is very easy to cut away a feature before you realize what is going on. Simple, direct methods that have been advocated are certainly commendable. There is

the simple method of putting a fixed point in front of the face. There are many ways of doing it, and this would be a very ideal way of doing it.

To get the jaw forward quickly, I have used a fishhook with the barb cut off, and stuck it under the chin. It is pulled forward quite easily that way.

One other word is that the use of sulfanilamide in these facial injuries is a distinct advantage, and many wounds will heal much quicker by the implantation of it. I have had the experience of having them heal.

One other point is that the use of wire through these jaws is of tremendous advantage in many instances where they need to displace two planes. Of course, you have to have wires in two planes, but they do away with complicated internal splinting, and let the patient open his mouth. Strangely enough, in the operating room, after the wire has been put in, the patient is comfortable in about five minutes.

I would like to digress and speak personally for a minute, to stay that I appreciate very much being in this Association and hope that I may gain new confidence in being a member of the Association.

DR. JOHN STAIGE DAVIS (Baltimore, Md.): There is no need for comment or emphasis on the character or the timeliness of this presentation. Everybody who is going to be subjected to a face or jaw injury in this war will have, I would say, at least a 100 per cent better chance—or I would put it a 400 per cent better chance—of coming out with reduced invalidism and resultant comfort because of the preparation that is being made and the character of the men who have charge of the thing.

The one thing that was always in my mind through the last war was a regret that I had never seen a war previously. It would have been so different. Doctor Ivy has the advantage and Colonel Stout has the advantage of having been through the game before and knowing first-hand what it is all about. I never did know what it was all about.

There is one thing that was discussed that I would like to emphasize, and to add something else. There are very few of the bad results of—I am sure of this—such things as the French are having, and wearing masks for, segregating them, putting them in blind asylums where people cannot see them, and that sort of thing, where the trouble was with the original injury. A piece of shrapnel can cut off a person's face, or a big piece can tear off the whole face, but it is rarely done. In that, and the long disability following burns, the really bad maiming of people from burns, short of absolutely burning off structures, the people who survive are the result of poor early treatment.

SCIENCE AND HUMAN PROGRESS—II

Astronomy and Optics

ASTRONOMY made necessary the study of optics. It has developed the strength of the human eye until it has become a two-hundred-inch reflector. It has, in the other direction, aided in the development of the microscope, until all the beneficent results of microscopic investigation are now in our possession and the end is not yet. The development of the study of optics and the correction of the imperfections of the human eye have given us the universal use of ordinary eyeglasses which has become one of the great factors in safety, in human enjoyment, and the advancement of education. Let us not forget, however, that the Chinese were two thousand years ahead of western civilization in the use of eyeglasses.

—A. Cressy Morrison. Transactions of the New York Academy of Sciences. Series II. 2. No. 3. January. 1940.

THE MEDICAL DEPARTMENT IN NAVAL WARFARE*

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WE FREQUENTLY HEAR the Navy spoken of as our first line of defense. If this is true, it then becomes the Navy's duty in time of peace to prepare and keep itself in immediate readiness for war. In warfare on land, the capture of an entire regiment, division, or even larger units is not unusual in these days. In naval warfare the mission of the naval commander is always the complete destruction of the enemy ship, force or fleet.

The Medical Department serves the line as a part of the military team, and to function properly must adapt itself to the conditions created by military tactics and operations; therefore, it is essential that those who serve as part of the medical units should have a good working knowledge of line tactics.

It takes many different types of ships to make an efficient fleet. With the time at hand it would be impossible to dwell at any length upon the individual functions of the medical personnel of these various units. We know that the mutual support and cooperation of these various highly specialized units is of the greatest importance in battle and that the highly differentiated functions of a modern naval medical service indicate that the duties of the medical officer on recruiting duty, in the laboratory, in the surgical operating theater, in the field, afloat, in the diving unit, and in the air, all converge toward the same objective, that of maintaining a readiness for war-time conditions.

The policy of our country in the past has been to maintain a small standing Army and Navy; therefore, when a national emergency arises, our armed forces must serve as a nucleus around which a much larger number of civilians and reserves will crystallize. For this reason it is fitting that the regular service medical officer, particularly in the latter half of his career, should develop a well-grounded knowledge in military medicine. When war comes he must be prepared to surrender his purely professional duties to an equally competent, available reserve officer and assume duties requiring long military experience.

Personnel.—All activities of the Medical Department of the Navy come under the direct supervision of the Bureau of Medicine and Surgery which was established by law in 1842. Personnel of the Medical Department is made up of: Medical and dental officers in the commissioned grades, pharmacists in the warrant grades, nurses who are not commissioned; and enlisted men, known as hospital corpsmen. Quotas for each of these categories have been established by the Congress. For each 1,000 enlisted men and officers

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on active duty in the Navy and Marine Corps, six and one-half medical officers are allowed. The allowance for dental officers is two per thousand, nurses three per thousand, and hospital corpsmen three and one-half per cent, or 35 per thousand.

The regular service obtains medical officers in two ways: (1) Graduates of Class A medical schools who have had an internship of at least one year may be commissioned as junior grade lieutenants, providing they meet the physical requirements and pass the professional examinations. (2) Recent graduates of Class A schools may be appointed as acting assistant surgeons and serve an internship of one year in one of our naval hospitals, and then be commissioned as assistant surgeons. The limitation of 100 appointments for acting assistant surgeons has been removed; the Secretary of the Navy is now authorized to appoint up to 300 interns a year. Several of our larger naval hospitals are now accredited for intern training by the Council on Medical Education and Hospitals of the American Medical Association. The Surgeon General has recently requested that the remaining naval hospitals be so classified.

When conditions permit, all recently commissioned medical officers are sent to the Naval Medical School, in Washington, for the course in indoctrination. Upon completion of this course, it is customary for them to go to sea. In due time they are encouraged to specialize. This postgraduate work may be accomplished in our naval hospitals or at the various civilian medical centers throughout the country.

Within the past few years the Navy has developed a well-organized reserve. The organization of these reserves by naval districts facilitates a peace time training program and simplifies mobilization. The Medical Corps of the Naval Reserve consists of three classes: (1) Organized Reserve (MC-O); (2) Volunteer General Service Class MC-V(G); and (3) Volunteer Special Service Class MC-V(S). The physical requirements for appointments in the Organized and in the Volunteer General Service Classes are the same as in the Medical Corps of the regular service. The maximum age limitation, however, for the General Service Class is 35 years instead of 32 years, as is required for the regular service. Appointments are made in the Organized Reserve from officers who hold commissions in the General Service Class by transfer. Officers of the Organized Reserve are required to attend a certain number of drills and to perform annual training duty, for which they receive remuneration. Officers of the Volunteer General Service Class and those of the Organized Reserve may be assigned to sea duty or any other duty where their services are required. The maximum age limitation for appointments in the Special Service Class, in less than 50 years of age at the time of acceptance of appointment. Officers of this class are not required to pass such a rigid examination and are recruited for shore duty, duty aboard hospital ships, and on foreign shore stations. There is no provision whereby these officers may be assigned to sea duty billets.

Also, in the Medical Corps of the Naval Reserve provisions have been

made for the establishment of a large number of Medical Specialists Units. Each of these consist of eight medical and one dental officer and when needed, six reserve nurses. These units are the nuclei for assignment to duty at naval hospitals, hospital ships, and medical department activities which may require a complete medical corps organization. These officers will act as "Heads of Departments" and one of their number is known as the "Organizer". The specialties represented are: general surgery; orthopedic surgery; internal medicine; psychiatry; pathology; urology; otolaryngology; roentgenology; and prosthodontia. In a national emergency these units will be placed on active duty in our naval hospitals which will release the regular service officers for duties requiring more military experience. Many of these units have been organized at teaching centers throughout the country and several of the principals are key members of medical school faculties. It is the Bureau's policy in case of war to disrupt teaching activities as little as possible, and for that reason each principal member of the Medical Specialists Unit has an alternate, who at the time of mobilization will proceed with his unit, if for any reason the principal cannot go.

In addition to the Medical Specialists Unit there is established one Laboratory Research Unit, which is now on active duty at the Medical School of the University of California, conducting research in the potency of influenza virus vaccine. This Laboratory Unit consists of two reserve medical officers and 12 enlisted men, all of whom are college graduates that have specialized in bacteriology. There are also established Mobile Epidemiologic and Sanitary Units, each of these consisting of two medical officers and four hospital corpsmen. The purpose of these units is to enable the Surgeon General to assign, hurriedly, a unit to any Navy or Marine Corps activity where research in an unusual or epidemiologic condition may be indicated.

Neurosurgical Units are also in the process of formation. They will be mobile, either by automobile or airplane and can be assigned to the various base hospitals where their services are required in an emergency.

The Surgeon General of the Navy is authorized by Naval Reserve Regulations to form "groups" of medical reserve officers for special assignment. In this connection, there is in the process of formation at this time one rather large Reserve Group at the Rockefeller Foundation where a number of the staff hold commissions in the Medical Corps of the Naval Reserve. This group can be broken up into small units and detailed for research activity where indicated.

The Secretary of the Navy recently approved changes in the Naval Reserve Regulations whereby it is now possible to offer appointments as ensign in the Naval Reserve to junior and senior medical and dental students who meet the physical and other requirements for such appointments. It is the policy of the Bureau of Medicine and Surgery to retain these ensigns on an inactive duty status until they have completed their medical and dental education, at which time their appointments as ensign are revoked and they become eligible to apply for appointment either as acting assistant surgeons (interns) or

as lieutenants, junior grade. In the event of mobilization, and if the services of a limited number of these ensigns are required, they may be called to active duty at a naval hospital in the vicinity of their school during the summer months only; but, insofar as practicable these officers will be retained on an inactive status.

All recruits upon entering the service as apprentice seaman go to a Naval Training Station for what is known as their "boot training." Following this, those who choose to enter the hospital corps are sent to one of our three hospital corps schools where they are given a four-months course in nursing and care of the sick. Upon completion of this course they are transferred to a naval hospital for duty where their training is continued under the supervision of the hospital staff for one year; they are then fit for general duty with the fleet.

A valuable reservoir of enlisted reserves has been built up in what is known as the Fleet Naval Reserve. This is made up of men who have voluntarily retired after 16 or 20 years active service. They, for the most part, are chief petty officers and upon recall to active duty form a good nucleus to build around. Male nurses, registered pharmacists and trained medical technicians in civil life may now be enrolled in the Volunteer Reserve (Class V-6). They will not be required to take recruit training and will be given petty officer and chief petty officer ratings according to their qualifications.

Medical Tactics.—Capital ships are not only built to deal out punishment but also to take it. With the present development of naval architecture and its extensive system of compartmentation there has been a great increase in the floatability of ships. Watertight and fumetight integrity of compartments in battle is of the greatest importance. These conditions have brought about the present system of damage control aboard combatant ships and have caused drastic changes in the arrangement of the medical department for battle and its function during battle. The care of casualties during battle must be considered as a phase of damage control, for material damage and personnel damage go hand in hand. Peace time training, therefore, is to this point.

Consistent with the importance of damage control on combatant ships, two fundamental principles are enunciated:

1. The watertight integrity of the ship, regardless of the wounded, must be preserved.
2. Fire-power, as delivered by the batteries of the ship, regardless of the wounded, must be maintained.

The medical personnel aboard a capital ship in war-time consists of three medical officers and one dental officer. There is also one hospital corpsman for each hundred of the ships company. With a war-time complement of 1,800 to 2,000 men there will be 18 to 20 hospital corpsmen aboard. This number will not permit a skilled medical attendant for each compartment. To insure the services of medical personnel after action, and to conserve the medical and surgical supplies and equipment, it is necessary that they be

distributed in two or more protected areas behind armor. For these reasons, during action, relative immobility is imposed upon medical personnel and this time is used to prepare material and equipment for the post battle rush and to drill hospital corpsmen in their duties.

The inability of medical personnel to get to the wounded at their stations, makes it necessary that all members of the crew be drilled in first aid measures. Men are taught to apply properly occlusive dressings, to apply a tourniquet to an arm or leg, to relieve suffering by the use of morphine supplied in *syrettes*, to apply a dressing to a burn, and to recognize the need for immobilization of a fracture and the care in moving men with fractures.

Prior to battle, first aid material in metal boxes is delivered to every vulnerable part of the ship, where it will be available for self or mutual aid. The supplies will depend upon the number of men in the compartment, the hazards of the position and the type of casualties anticipated. In the turrets and other large compartments where accidents are apt to occur, selected lay members of the crew are especially trained in first aid measures and it becomes their duty to handle the casualties. Two per cent of the ships crew is instructed in transportation of wounded. These men are usually the ships bandsmen and make up what is known as the ambulance party.

During action aboard a combat ship all watertight doors and hatches are controlled by central station. When damage occurs in any part of the ship and it is possible to modify the tightly closed condition of the ship, repair parties move to make such repairs as are possible. Accompanying these parties will be one or two hospital corpsmen and stretcher bearers who will give what aid they can and move the severely wounded to or toward the battle dressing station.

Immediately upon cessation of battle or during a lull in action, the medical department has its greatest opportunity to contribute directly to the military efficiency of the ship by: (1) Restoring to fighting efficiency the wounded men made ill by prevailing battle conditions, and those incapacitated by the milder effects of chemical agents. These will find their way by designated routes to the proper dressing station. (2) To clear the gun and other battle stations of the more seriously wounded. These must be helped or carried to the battle dressing or chemical decontamination station. (3) To treat those whose injuries incapacitate them for duty. These operations are set down in chronologic sequence in which they must be completed; actually there will be some overlap in their execution.

In a lull, or after action, temporary dressing stations should be established on upper decks for the care of slightly wounded, which procedure automatically serves to filter out those from the seriously wounded who need more detailed treatment at the regular battle dressing station.

It is of the greatest military and humanitarian importance that all severe battle casualties be removed from fighting ships at the earliest possible time. Manual transportation from the battle stations to the dressing stations is usually more expeditious than by the use of litters; canvas chutes or slideways

between decks are of great value. Upon cessation of hostilities, stretcher parties are sent out to all parts of the ship and the wounded brought in to the battle dressing station and here they are sorted out. Dressings are arranged and wounds checked for hemorrhage; if tourniquets have been applied they will be released and attempts made to control hemorrhage by compression dressings or by tying off active bleeders, for it is possible that tourniquets cause more deaths than they save lives. Prophylactic shock treatment will be instituted by giving hot drinks, food and water, morphine for pain, and the proper splinting of fractures. No attempt will be made to evacuate patients in active shock until this condition has been controlled. Blood plasma transfusions will be available and although the blood type of all members of the crew will be known, ordinarily, insufficient time will be available for cross-matching and whole blood transfusions. Patients for priority evacuation will be so tagged. Antitetanic serum will be administered and chemotherapy will probably be started at this station. The lesser wounded will be dressed and returned to their stations for conservation of crew. Major operations that can be deferred with safety will not be performed at dressing stations but will await more favorable conditions in a hospital ship or shore station. It is, however, possible that, owing to the lack of supporting hospital facilities, definitive treatment of the wounded must be undertaken aboard combatant ships, and for this reason equipment and material is always at hand and peace-time training of personnel always embraces this possibility. One of the three medical officers assigned to each capital ship will be a qualified surgeon.

Wounds of naval warfare are characterized by their great extent, their multiplicity and the frequency with which secondary as well as primary missles and portions of clothing are driven into the tissues; sepsis may be expected in all of them. Burns are frequent, being either due to blast from exploding shells or bombs, burning powder, cordite, or fuel oil. Scalds from bursting steam lines are more common on destroyers than on larger ships. A bomb exploding in a compartment below decks will set up a blast wave which, in its search for an exit, will proceed along passageways and air ducts and may cause burns at some distant part of the ship. The lightest type of clothing will give protection against these burns and light face masks and gloves will protect the exposed parts. We have been told in the past that tetanus does not follow wounds aboard ship; this has not been borne out in the present war as the English have reported both tetanus and gas gangrene. We are now in the process of actively immunizing with tetanus toxoid all of our marine troops and their accompanying medical personnel. It is possible that this will be extended to all naval personnel in the near future.

The most common location of wounds are on the head, neck and upper extremity. This is apparently due to the downward angle of the flight of the projectile. There are few chest injuries and wounds of the back and buttocks are comparatively rare.

Paradoxically as it may seem, the engaged side of the ship is safer than

the unengaged; this is due to the fact, as shown by Stokes, that fragments of a bursting shell form a cone with the base toward the unengaged side. For this reason the wounded at the battle stations should be left on the engaged side, out of the way of the guns' crews, unless a sheltered position is available on the unengaged side; even then there is danger of grouping the wounded together due to the possibility of a direct hit on that point of concentration.

New weapons of destruction are constantly being developed which call for newer methods of prevention of casualties. The efficiency of aircraft has made it necessary to build armor in decks of capital ships and to provide more protection to guns' crews on the upper decks. Bombs missing ships but falling in the immediate vicinity, explode with such violence that glass in port holes is shattered with resulting casualties in the compartments. This means that new ships must be built without port holes and those in the older ships blocked out. It took the British only a short time to find the antidote for magnetic mines. This process of demagnetizing, commonly known as degaussing, has been applied to all of our ships. A mine exploding beneath a ship may cause such a violent upheaval of that part of the ship that not only feet and legs are fractured but intracranial injuries are sustained by the upward thrust against the overhead.

Nothing has occurred in the present European war to disprove the fact that the battle-ship is still the back-bone of the navy. These ships are heavy, comparatively slow but are built to take punishment. In battle, their casualty lists may be comparable to those in a regiment during a hard drive. Their medical departments must be entirely self-sufficient. A six-month supply of medical stores are aboard at all times. Light unarmored forces, destroyers, submarines and cruisers are likely to be sunk or escape with little damage. Air force casualties may be heavy but they will require little treatment or evacuation; the same can be said for submarines. The fleet that has air control can anticipate comparatively few casualties from gas of men exposed in the superstructure of ships.

The ratio of the casualty rate of a superior force to the casualty rate of an inferior is out of all proportion to the ratio of their fighting powers. This was apparent in the Spanish-American war, where our losses were negligible while those of the Spanish were severe. It was seen again in the recent battle between English and Italian vessels in the Mediterranean.

Farenholt and other authorities state that two fleets of equal strength will probably inflict about 20 per cent casualties on each other before one or both withdraw. As the size of the fleets increase, the percentage of the casualties will as a rule decrease. These estimates have been based on experience of past battles; with the present extensive use of aircraft and submarines they may be too low. The use of gas might also increase the percentage markedly.

In all past naval battles statistics have shown a high ratio of killed to wounded, it being placed at about 1 to 1. Drowning is a major factor which is not present in land warfare; the high mortality rate in modern turrets acci-

dents is also a factor. In the recent battle near Montevideo between three British cruisers and the Nazi pocket battleship, Graf Spee, 200 casualties resulted, 112 being killed and 88 wounded. Following the sinking of the Southampton by bombs the British reported a casualty list of 92, 90 per cent of which were killed. The individual ships will show a wide variation in the percentage of cause of deaths; for instance, on one ship practically all deaths will be due to shell wounds, on another it will be all burns and still another all drowning. The latter is responsible for more deaths than all other causes combined.

There will always be a marked discrepancy between the force casualty rate and the maximum casualty percentage for individual ships, as some ships will be heavily hit while others will escape entirely. The wounded percentage should be given primary consideration in developing medical plans for action. Allowing a margin of safety, we may assume that the maximum number wounded on individual capital ships will be 15 per cent of the ship's complement. It is this maximum wounded rate of individual ships that determines the medical and surgical war-time requirements for this type of vessel, while the force-wounded rate serves as a basis for computing the evacuation facilities, and this figure is used in determining the bed accommodation to be furnished by hospital ships or shore stations.

Evacuation of wounded from combatant ships may be by direct transfer from ship to shore or indirectly by the use of small ambulance boats; they may also be transferred to other vessels as hospital ships, hospital transports or other combat ships. When conditions permit, it may be advisable to evacuate the severely wounded by air ambulances. It appears in the present war, as in World War I, that hospital ships enjoy no immunity from attacks by the enemy. In the last war our Government found it a safer procedure to bring home the wounded from France by returning convoyed troop transport than by the use of unconvoyed hospital ships.

Hospital ships may be divided into two types: Class "A," or fleet hospital ships; and Class "B" or medical transports. In time of peace Class "A" hospital ships travel with and serve the fleet as floating hospitals. During action their function remains about the same but for many reasons they cannot be in the neighborhood of action. Their location will, therefore, depend to a great extent upon the distance of action from an established naval base. One of the prime requisites of an hospital ship is its ability to transfer patients speedily from another ship at sea and to a hospital ashore. Class "B" hospital ships are designed to function primarily on the line of communication, transporting medical material and personnel to the theater of operation, and evacuating from this area. The longer the lines of communication the nearer this class will approach Class "A" in equipment and construction. They may be converted merchant vessels, preferably around 7,000 tons displacement and with a speed of 10 to 16 knots.

Standardization of equipment, supplies and installations constitutes one of the fundamental principles underlying all military organizations. Con-

sistent with these principles the plans for hospital facilities for use in a national emergency include three types of hospitals:

1. Station hospitals of 100 to 200 bed capacity.
2. Mobile base hospital of 500 bed capacity and capable of expansion to 1,000 beds.
3. Naval hospitals, existing institutions of varying sizes and capable of expansion to meet the local needs.

In joint army and navy operations the navy assumes responsibility for the safe transportation of all material and personnel to and from the theater of operations. This arrangement places all troops and patients, while enroute, directly under the supervision of the Naval Medical Service. The duties of medical personnel of the navy when serving with the Marines brigaded with the army, as occurred in France in the last war, become identical with that of the Army Medical Service. The fleet at all times is prepared to put armed forces ashore; with these forces may go field hospital equipment carried aboard hospital ships. Each ship's medical department is trained and ready to accompany landing parties ashore.

In this highly mechanized type of modern warfare, equipment, material and specially trained personnel are of the greatest importance in deciding who the victor shall be. There is, however, another factor that we must not lose sight of, that is morale. It is an intangible, dynamic element that makes it possible for an inferior force to defeat a superior force. Units of the Fleet during peace-time are constantly undergoing drills simulating battle conditions. This frequent repetition of drills, the confinement aboard ship, the cramped quarters and the long periods at sea all favor a boresome life with lessening of morale. There is no officer aboard ship that can do more toward the maintenance of morale than the Medical Officer. His sympathetic handling of the routine sick and injured during peace-time, his constant interest in the crew's welfare, his instruction of the crew in first aid, and the efficient and expeditious manner in which he and his associated medical personnel handle simulated casualties during battle drills, all go toward the establishment of confidence in the minds of the crew; and who can say that morale is not based on confidence, confidence not only in one's self but confidence in one's ship and shipmates.

Many of the answers to medical problems that will arise during a national emergency are known; some of these, in the cause of national security, cannot be divulged at this time. The answers to many others are still unknown and will remain so until bitter experience arrives as the teacher. We, as medical officers, must be prepared to accept this new, total war, and to revise our medical tactics so that they will serve the line to its best advantage.

In concluding I know of no fewer words that summarize the mission of the Medical Department of the Navy than those found on the cover of the Naval Medical Bulletin: "To keep as many men at as many guns as many days as possible."

OUTLINE OF MEDICAL ORGANIZATION

Land Warfare	*Sea Warfare*
Firing line	Fighting portions of ship (local aid posts)
Company aid posts	Temporary dressing station (lay)
Battalion dressing station	Battle dressing station during battle
Collecting company	Ambulance parties
Clearing station Surgical hospital	Post combat station, sick bay and operating rooms
Ambulance battalions (corps, army)	Small ambulance boats
Evacuation hospital	Hospital ship if available, otherwise sick bay or advanced base or mobile hospital
General hospital	Shore hospitals, either station, base or naval

Much of the material in this article has been taken from the writings of Rear Admiral P. S. Rossiter and Captains W. L. Mann, Lucius W. Johnson and C. J. Holeman, all of the Medical Corps of the United States Navy. To them I express my appreciation.

FINNEY-HOWELL RESEARCH FOUNDATION FELLOWSHIPS

AT THE meeting of the Board of Directors of the Finney-Howell Research Foundation, Inc., 1211 Cathedral Street, Baltimore, Md., the following annual fellowships were awarded:

Dr. Glenn Horner Algire, to work at the National Cancer Institute, Bethesda, Md.

Dr. Earl Leroy Green, to work at the Jackson Memorial Laboratory, Bar Harbor, Me.

Dr. Joseph Gilbert Hamilton, to work at the Radiation Laboratory, University of California, Berkeley.

Dr. Rose I. Shukoff, to work at the Glasgow Royal Cancer Hospital, Glasgow, Scotland.

Fellowships were renewed for a year for Drs. Margaret Nast Lewis, Bernerd E. Kline, Julius Charles Abels, Alfred Marshak, John F. Menke and Paul C. Zamecnik.

Fellowships carrying an annual stipend of $2,000 are awarded for the period of one year, with the possibility of renewal up to three years, at the annual meeting of the Board of Directors, held the end of February.

Applications must be made on the blank forms furnished by the Secretary, and must be filed in the office of the Foundation *before* January 1 of each year.

Fellowships are awarded only for research into the cause or causes and the treatment of cancer.

ORGANIZATION FOR EVACUATION AND TREATMENT OF WAR CASUALTIES *

COLONEL NORMAN T. KIRK, M.D.

WASHINGTON, D. C.

FROM THE WALTER REED GENERAL HOSPITAL, U. S. ARMY MEDICAL CENTER, WASHINGTON, D. C.

THE STRENGTH OF THE ARMY before the present mobilization was 230,841. By July, 1941, it will have been increased to 1,400,000 officers and men consisting of:

Regular Army	375,000
National Guard	225,000
Selective Service	800,000
	1,400,000

The Medical Department is an administrative, technical, and supply service. It is charged with the preservation of the health of the Army; the professional care of the sick and wounded in peace and war; the procurement and training of its commissioned personnel in the Medical, Dental, Veterinary, Medical Administrative, and Sanitary Corps, the Army Nurse Corps and attached civilians, dietitians, physiotherapy aides, clerks, and others, and for the training of the enlisted men of the Medical Department. It is also responsible for the procurement, storage, and issue of all equipment and medical supplies necessary for the preservation of health, the equipping and maintenance of hospitals, Medical Department field organizations, and other installations.

Love's[1] statistics of the World War show the daily admission rate, seasoned troops, nonbattle casualties, to be 1.40 per 1,000. The average hospitalization of this casual sick group was 27.29 days; increasing this factor to 1.5 to cover seasonal variation, treatment beds are estimated as:

Daily Admission Rate per 1,000		Average Days in Hospital		Beds Required per 1,000
1.5	×	27.29	=	40.9 or 4.09%

allowing additional beds for dispersion, 5 per cent is considered the minimum bed requirement. Proposed strength 1,400,000 × 5 per cent = 70,000 hospital beds required for the first year's training period. The following number of beds are being made available for July 1: 4 per cent in camp hospitals (based on the strength of that camp), 1 per cent in general hospitals, the latter being placed strategically throughout the country.

Hospital beds available prior to mobilization in Army hospitals	11,280
New general hospitals being constructed (beds)	10,000
Cantonment hospitals (beds)	50,000

* Read before the American Surgical Association, White Sulphur Springs, W. Va., April 28–30, 1941.

Personnel Requirements.—For this training period, 6.5 medical officers per 1,000 strength are required. In war, this requirement is raised to 7.5. Nine thousand and one hundred medical officers will, therefore, be required as of July 1, 1941. There are now on duty (March 30):

Medical Corps, Regular Army	1,230
Medical Corps, National Guard	560
Medical Reserve Corps—active duty	5,000
	6,790

There were 14,000 officers in the Medical Reserve Corps who became subject to the call of the President by an act of Congress. Many younger physicians have been commissioned in the grade of first lieutenant, and have volunteered for a year's extended active duty, in addition to the original 14,000.

There are ample Dental, Veterinary, M.A.C., and Sanitary Reserve officers to meet the present needs.

Nurse Corps.—The requirements are four per 1,000 strength, or one nurse per ten patients. There are now on duty:

Regular Army Nurses	1,243
Reserve Army Nurses	1,748
	2,991

Some 2,400 additional nurses will be required by July 1. This is entirely volunteer service and the Red Cross assists in procurement from its reserve nurse enrollment.

Enlisted Personnel.—The requirement for enlisted men for duty with Field Units, as clerks, hospital technicians, orderlies, dental, and veterinary technicians is 48.5 per 1,000. Two training replacement centers are being established, and some 19,000 draftees are to be sent to our general hospitals and service schools for training as technicians in surgery, medicine, laboratory, roentgenology, dental, veterinary, and other specialties.

It was thought that this brief outline of the Medical Department problem during this year's training period might be of interest before we considered the plan for evacuation and treatment of war casualties.

Each regiment of infantry and, likewise, all other military units in the field have attached medical troops. The present infantry regiment has a strength of 3,448 officers and men, consisting of an headquarters and headquarters company, three battalions of four companies each, and certain other units. The attached medical troops are known as the Regimental Medical Detachment. The senior medical officer is the Surgeon, with the rank of Major. He is on the special staff of the Colonel commanding the infantry regiment. The war strength of the Regimental Medical Detachment is eight medical officers, two dental officers and 96 enlisted men. This detachment is organized into a regimental headquarters section and three battalion sections. The regimental surgeon heads up the regimental headquarters section, and he assigns one of his junior medical officers as battalion surgeon to command

each battalion section and to serve the infantry battalion to which attached. In combat, the regimental surgeon establishes his regimental aid station in close proximity to regimental headquarters and takes care of casualties in the regiment other than those pertaining to the battalions, directs the battalion surgeons and advises his commanding officer concerning regimental casualties. Each battalion surgeon establishes his battalion aid station, renders first aid with his enlisted personnel to the casualties of his battalion and advises his battalion commander concerning casualties of the battalion. Two enlisted men of this detachment are assigned to each infantry company as first-aid men. They proceed with that company in combat to render first aid in front of the battalion and regimental aid stations.

The Regimental Medical Detachment is the backbone of medical service rendered to troops in combat. The regimental surgeon must at all times be conversant with the tactical situation, the intentions of the regimental commander and is responsible for the health of the command in camp, on the march, and in combat, and for rendering first aid to all battle casualties, and for their proper care and evacuation.

The battalion aid station is established some 300 to 800 yards behind the firing line of the battalion it supports. It should be sheltered from the direct rifle fire and be near water, if available. The equipment is carried by truck and consists mainly of bandages, drugs, splints, blankets, A.T.S., tentage, and food. The casualties, as they occur in an infantry company, are given first aid by the two company aid men attached to the company from the battalion aid section. They also direct the walking wounded to the battalion aid station. The litter bearers of the battalion aid station come forward to apply occlusive dressings, splint fractures, administer hypnotics, and carry the litter patients back to the battalion aid station. At the station, the dressing section further dresses wounds, splints fractures, administers stimulants, A.T.S., and treats shock and gas cases, and gives nourishment in the form of soup, chocolate, and coffee. They collect and tag all wounded, showing the nature of the wound and treatment given. Patients are cared for under shelter while waiting and are prepared for further evacuation (Fig. 1). From this point to the hospital station, the evacuation is carried out by the personnel of the medical regiment. A collecting company of the collecting battalion comes forward and establishes a collecting station 1,000 to 2,000 yards behind the battalion aid stations, one collecting station being established ordinarily for each two infantry regiments in combat. This station is a bit more elaborate than the battalion aid and has a larger personnel. Its litter bearer section evacuates litter patients by litter-carry or wheel-litter from the battalion aid stations to this station. Casualties are here administered to, fed, sheltered, and redressed as indicated until evacuated by the ambulances of the ambulance company.

The hospital station is established from four to five miles behind the collecting station. It is out of rifle range and should be so located as to be

sheltered from direct artillery fire, near a good road leading to the rear, and away from any artillery emplacements, ordnance dumps, or other troop concentration points. Tentage is pitched to shelter the wounded if available buildings are not at hand. Various departments are set up as:

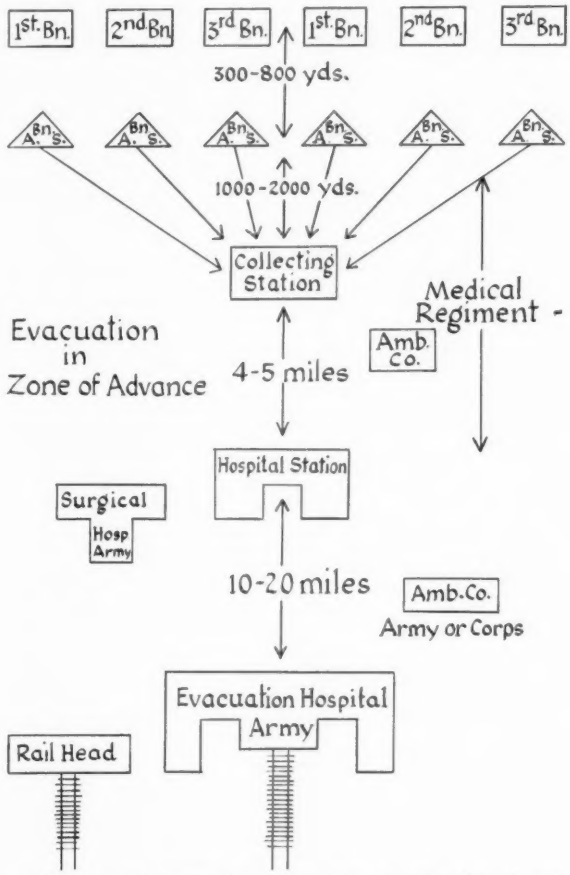


FIG. 1.—Diagrammatic representation of evacuation of war casualties from the Battalion Aid Station by the Medical Regiment to the Hospital Station (Divisional) and by ambulance companies (Army) from the Hospital Station to the Evacuation Hospital. (Bn. A. S.—Battalion Aid Station.)

Receiving Department or Triage.—All cases are critically examined on admission. Those found fit for duty are immediately returned to their organization. Those in shock are sent to the shock section for treatment. Those who need adjustment of splints or are suffering from hemorrhage or require redressing are sent to the surgical section. The medical cases are sent to the medical section or, if able for evacuation, to the evacuation section. Gunshot wounds of the head, abdomen, and chest, those suffering from severe hemorrhage, and the moribund are immediately transported to the adjacent surgical hospital which has been established by the Army. All others are sent to

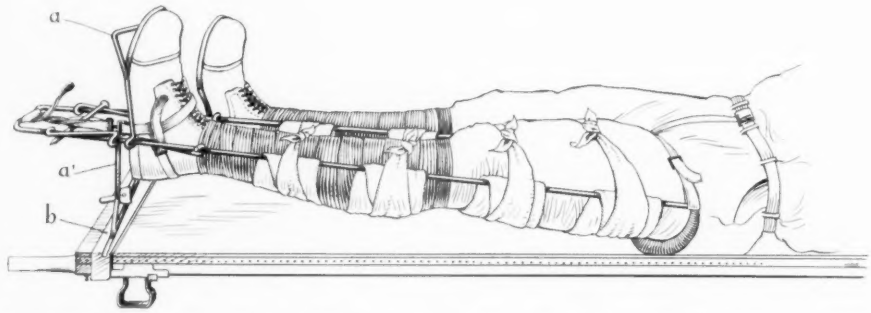
the evacuation section where they are housed, fed, and made comfortable until evacuated. Evacuation from the hospital station is carried out by ambulances or trucks from the Army to the evacuation hospital which is located in the Army area on a rail head some 15 to 20 miles to the rear. Only minor surgery is attempted in the hospital station, but intravenous fluids such as salt solution, acacia, and blood plasma will be available for the treatment of shock.

Surgical Hospital (Army).—The surgical hospital is an Army unit which is sent forward into the divisional area and established in the neighborhood of the hospital stations for the treatment of severely wounded who will not stand transportation to the rear. It represents a small evacuation hospital brought forward. It has a bed capacity of 250, full surgical facilities for extensive emergency operative procedures, and its personnel is supplemented by surgical, splint, and shock teams from the G.H.Q. reserve.

Evacuation Hospital (Army).—The evacuation hospital is established on a rail head, having a capacity of 750 beds and is housed in existing buildings or in its own tentage. This hospital is completely equipped to give adequate emergency surgery. Time will not permit a detailed account of its complete organization and function. All patients admitted are critically examined and separated into certain classes, *i.e.*, slightly wounded, seriously wounded, those in shock, bleeding cases, gas cases, medical cases, compound fractures, *etc.*, and appropriate steps are taken so that treatment may be instituted at once. Patients in shock are sent immediately to the shock wards for treatment, medical cases to medical wards, slightly wounded to dressing rooms for slightly wounded, then to the adjacent convalescent hospital (Army), with the venereals and convalescent patients who are held in the Army area. Hemorrhage cases and compound fractures are sent at once to surgery, unless in shock. The priority in treatment is determined by the chief of the surgical service on the urgency and severity of the case. All wounds are thoroughly débrided after fluoroscopic study for foreign bodies and the nature and extent of fractures. Shock is treated by intravenous replacement, using salt solution, acacia, blood plasma, or whole blood. Fractures are resplinted after surgery, using traction-fixation splints with skeletal or skin traction as required. Patients are then put to bed, fed, and cared for until evacuated by hospital trains to general hospitals in the line of communications for definitive care. The personnel of the evacuation hospital may be supplemented by surgical, shock, splint, and gas teams from the G.H.Q. reserve.

Love's[1] statistics of World War I show that better than 30 per cent of all war casualties admitted to the evacuation hospital present compound fractures (Fig. 2). The British in this war had a mortality of 50 per cent in compound fractures of the femur, occurring between the battalion aid and their casualty clearing station, corresponding to our evacuation hospital. The Liston splint and other types of board coaptation splints were the types of splints employed during this period. They strongly considered going back to the days of Baron Larrey and recommending primary amputation in these cases in

the battalion aid stations to lessen this fearful mortality. Through the efforts of Sir Robert Jones the British Army adopted the Thomas splint for the splinting of fractures of long bones or lower extremity. After the adoption and use of this splint the mortality dropped from 50 to 15 per cent, from splinting alone, and the number of cases arriving at the evacuation hospital in shock



Immobilization for transportation of major fractures of lower extremity. a-a'—Interchangeable splint support and foot rest. b—Litter bar, model 1932.

FIG. 2.—The Keller hinged half-ring splint properly applied for fixed traction transportation of fracture of the femur, knee joint, or both bones of the leg above the ankle. In a compound fracture the clothing is just cut away and an occlusive dressing applied. (Taken from the Army Splint Manual.)

was markedly reduced. Death early in compound fractures results from hemorrhage and shock—later from infection. Proper splinting, then, during transportation, lessens shock, and lessens further contamination in compound wounds. Pain, incident to transportation, is likewise reduced; débridement of the wound and reduction of the fracture and its definitive care is rendered less difficult. Proper splinting also prevents further damage to soft tissues and the blood supply of the extremity. The Thomas splint was modified by Colonel Keller of the Medical Corps of our Army, becoming the Army-hinged half-ring splint which was adopted by our forces. It is used in splinting of all fractures of the femur, those about the knee joint, and both bones of the leg above the ankle. The Murray-Jones traction humeral splint (Fig. 3) is a similar splint adopted for the upper extremity. This splint is used in fractures about the shoulder, in the humerus, about the elbow joint and the upper third of the forearm. In fractures about the ankle and foot, the Army ladder-wire splint (Fig. 4), and shell wound dressings for padding are used. The ladder-wire is held in position, fixing the foot at a right angle, by a muslin bandage.

Gunshot fractures, occurring in action, are splinted as indicated above by the litter bearer section of the battalion medical section and are littered back to that station. The clothing over the wound, before the splint is applied, is cut away, the wound is painted with tincture of iodine, using the iodine swab which is carried by the medical soldier. An occlusive dressing is applied and the extremity splinted. When the patient arrives at the battalion aid station he is given 1,500 cc. of A.T.S., if he is not immune to tetanus, and

60 gr. of sulfanilamide at once, to be followed with 15 gr. every four hours thereafter during his transportation to the rear and for the next week. This drug acts as a prophylaxis against pyogenic and anaerobic infections. His splint is readjusted if indicated, a litter is prepared with blankets in such a manner that the patient lies on parts of two blankets which are later folded over him, and a third blanket is placed over these to maintain body heat (Fig. 5), thereby lessening shock. The end of the Keller splint is supported on the canvas of the litter by the splint support and made fast to the handle of the litter by a muslin bandage. The patient, now, if not in shock, is ready for transportation by litter-carry to the collecting station. If his blood pressure is under 100, shock is present or imminent, and this must be treated before he is transported. He is given morphine for relief of pain and to lessen muscle spasm. Sodium amytal may be given, as it has been proved in animal experimentation to delay the development of shock. If his condition is satisfactory on arrival at the collecting station, he is placed in an ambulance with other wounded and transported to the hospital station. On arriving here, if in shock, he is admitted to the shock section, and his shock treated. If he is bleeding, if his dressings have become soiled, or his splint needs readjusting, he is sent to the surgical section. He is not removed from his litter, on which he was orginally placed, until he arrives at the evacuation hospital, unless his condition or the condition of the litter demands it. He is then put in the evacuation ward of the hospital station and by an ambulance from the Army or by airplane ambulance he is evacuated to the evacuation hospital. If he is bleeding badly and ligation of a vessel or amputation is necessary to save his life, he is transported to the adjacent surgical hospital for immediate surgery.

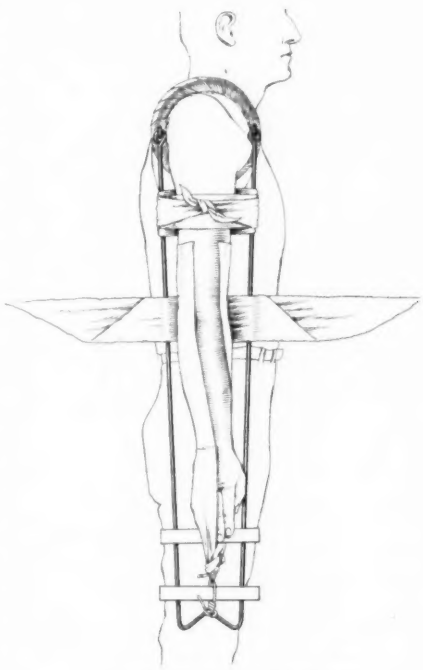
TABLE I

BATTLE CASUALTIES: GUNSHOT WOUNDS IN THE A.E.F. WITH RATES PER 1000 TOTAL CASES; AND PERCENTAGE OF DEATHS PER EACH LOCATION*

	Frequency per 1,000	Percentage Death Rate
Soft tissues, upper extremity	198.61	4.27
Compound fractures of hand and wrist	118.23	1.47
Compound fractures of clavical, humerus, scapula	32.74	9.46
Compound fractures of radius and ulna	30.24	4.36
Large blood vessels and nerves, upper extremity	13.36	7.11
Soft tissues, lower extremity	333.86	6.09
Compound fractures of femur, tibia, fibula, knee joint	70.52	17.53
Compound factures of ankle and foot	65.79	2.56
Compound fractures of pelvis	4.22	26.98
Large blood vessels and nerves, lower extremity	3.33	11.90
Soft tissue of face and head	59.19	2.31
Bones of face	10.24	8.45
Cranial bones and brain	20.46	37.11
Spinal cord and vertebrae	3.64	55.85
Chest wounds	10.52	47.68
Abdominal wounds	11.07	66.80

* The above table is included to show the relative number and types of war wounds that will require treatment by various surgical specialist groups at the Evacuation and General Hospitals.

He arrives at the receiving ward of the evacuation hospital on his original litter (Table I). If in shock, he goes to the shock section for treatment, if not, he is undressed and bathed, insofar as possible without the removal of the splint. He is then sent to surgery via the roentgenologic department, where the roentgenologist, by fluoroscopy, determines the site of fractures and the presence or absence of foreign bodies. He describes his findings by sketching and in writing to the chief of the surgical team on whose table the patient is placed. The patient is anesthetized, spinal anesthesia is used if he is not in shock, the splint team removes the splint, maintaining traction on the extremity while it is prepared for surgery. The wound is débrided, *i.e.*, the skin around the wound is thoroughly cut away, as is the rent in the fascia, the incision is increased in length both in skin and fascia so that all traumatized muscle may be exposed and removed, large blood vessels and nerves are avoided, all foreign bodies are removed, as are fragments of bone not attached by the periosteum to healthy muscle and those which have not adequate blood supply. The wound is thoroughly irrigated with normal salt or Dakin's solution and, after all vessels are ligated, several grams of sulfathiazole are sprayed into the wound, and it is packed open with paraffin-soaked or B.I.P. gauze. The surgical team having finished its work, the splint team reapplies the Army half-ring splint, using either skeletal or skin traction to maintain length and alignment. The patient is now transported in fixed traction to the ward for a few hours or days to await transportation by hospital train through the line of communications to a general hospital for definitive care.



Hinged traction arm splint.

FIG. 3.—The Murray-Jones humeral traction splint for immobilization of fractures about the shoulder, humerus, elbow and upper third of the forearm. (Taken from the Army Splint Manual.)

Primary closure of wounds after débridement was banned by order during World War I because of severe infections that too often followed this procedure. Even with the advantages of the new chemotherapeutic drugs, it is as yet considered too hazardous. All of us are agreed, I think, that a thorough débridement is indicated, but following this, there is quite some disagreement in the handling of compound fractures.

Orr[2] recommends the packing of the débrided wound with vaselined gauze after the reduction of the fracture, the application of an encasement to the

extremity, using a through-and-through pin above and below the fracture site to maintain reduction.

Trueta[3] packed the wound with plain gauze and applied a skin-tight plaster casing, the so-called "closed method." He reports 1,073 patients so treated in his hospital, and in only eight of these cases did he have to remove the encasement because of infection, and in only one case did gas infection occur.

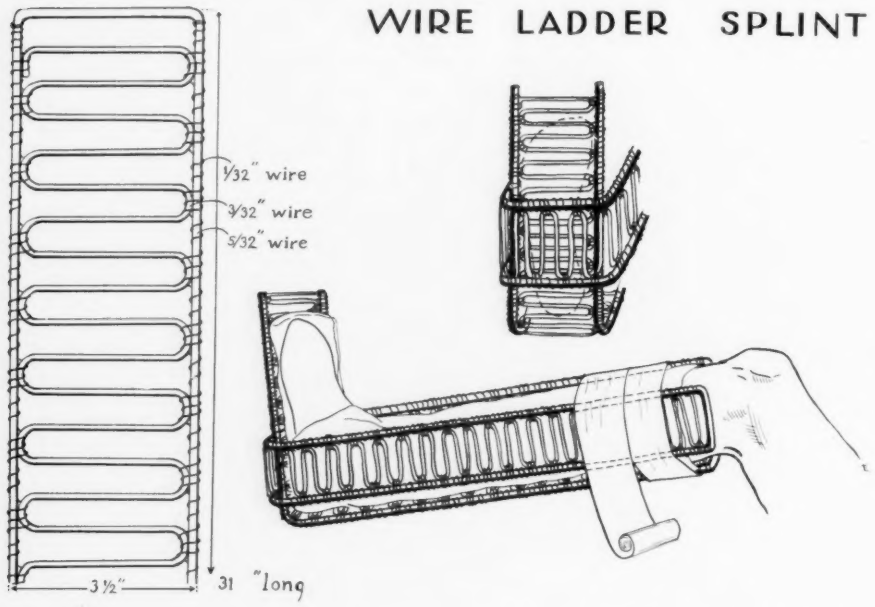


FIG. 4.—The wire ladder-splint is used for immobilization of fractures about the ankles and foot, using gauze and cotton or shell wound dressings as padding. (Taken from the Army Splint Manual.)

He further states that some 10,000 wounded treated by the "closed method" arrived in France after the retreat from Catalonia. He states "the general consensus of opinion (French surgeons) was that the results were entirely satisfactory," and that Arnaud found only one case of gas gangrene in 800 wounded which had been so treated.

Arnaud, *et al.*,[4] in February and March, 1939, observed 2,000 wounded who had survived the exodus from Spain to France, 600 of whom had been treated by the "closed method." They found that soft tissue wounds had healed satisfactorily, 50 per cent of the compound fractures showed "mediocre results," mal- and nonunion, deformity, excessive soft callus with multiple sequestral and fibrosed joints and muscles. The best results were in the upper extremity, particularly in the metacarpals. All fractures of the femur showed bad results and no wounded joint was without complicating infection. Many showed suppurative dissections of the subcutaneous and subaponeurotic tissues, particularly of the thigh and calf, with secondary joint involvement or metastatic abscess. These cases showed no clinical evidence of suppuration

such as edema, temperature elevation or pain, but many looked cachectic and suffered from diarrhea. Arnaud does not advise the systematic use of the "closed method," believes it permits evacuation in excellent condition without great risk, but that it should not be used in definitive care of compound fractures.

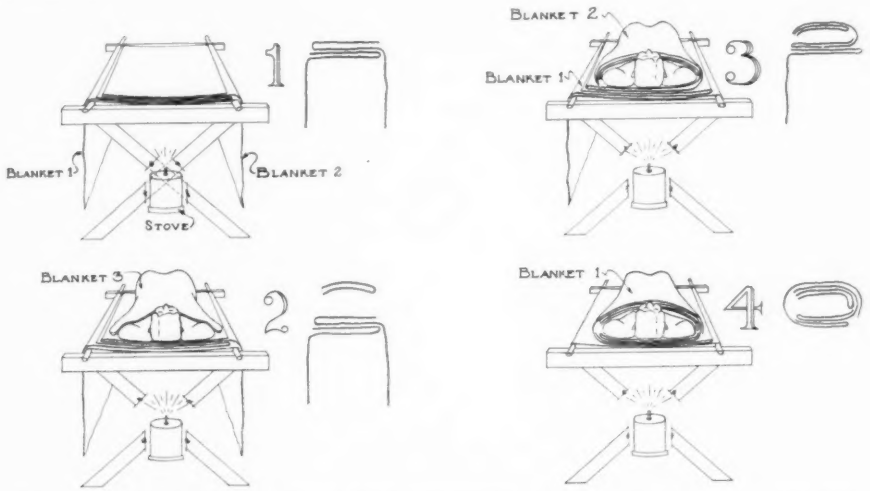


FIG. 5.—Proper blanketing of wounded before transportation is essential to maintain body heat and lessen shock—an accepted method. (Taken from the Army Splint Manual.)

He states that Ollier, in 1872, described the "closed method," at a medical congress in Lyon, as "concerning irremovable occlusion as a general method of dressing of wounds and its application to Army surgeons."

To quote M. Picot[5] "—in a fresh war fracture, contrary to Bastos, . . . , Soulie, and Linares, the most important point is not the bone; it is the soft tissue. It is not from the femur that gas gangrene will come; it will come from the fleshy masses of the thigh and buttock. In the leg it is not in the tibia that the anaerobes will swarm, but in the calf muscles." To quote further: "The particular gravity of the vascular lesions which complicate large fractures is well-known—all agents which place an obstacle in the way of the circulatory system of a fractured member—a circular encasement, plaster ring, *etc.*—can have the same consequences . . . following the postoperative swelling of the member."

Sherman uses internal fixation when applicable, *i.e.*, stainless steel plates and screw, leaves the wound open, dakinizes it with stable hyperchloride solution followed by secondary closure. Clay Murray likewise recommends internal fixation.

Wilson, in his work in London, adapted the Roger-Anderson dual pin reduction fixation method for definitive care of gunshot fractures of long bones after débridement, and insufflation of sulfathiazole and a pack of vaselined gauze followed by the application of a plaster encasement.

This method is too complicated for adaptation to military use in the

evacuation hospital, but can be considered as a method for definitive care in general hospitals. From my personal observation in a limited number of cases of simple fractures treated by this method, I consider it much more dangerous from complicating bone infection than open reduction and internal fixation.

It is hoped that some method of treatment of compound gunshot fractures will be evolved that is superior to the suspension, skeletal traction method, using either a medicated pack or dakinization.

Our present plan for evacuation of battle casualties may not be sufficiently elastic to meet the more difficult problems presented by a warfare of motion with rapidly moving mechanized forces, but some plan is essential as a working basis. Even in fixed warfare of the type our Army fought in France, battle casualties too often arrived at the evacuation hospital long after the six-hour period of wound contamination.

DISCUSSION.—COMMANDER W. D. WILCUTS (U. S. Navy): The Surgeon General had expected to be here this morning. He sends you his cordial greetings and warmest thanks for the aid and the help you, as an organization and as individual members, are extending him. I came down here unexpectedly, but he wished me to stress just the high points of what the Navy needs to-day.

We like to think of the Navy as the first line of defense, as being ready. Off the record, may I say that we are ready. We are ready for anything in the western hemisphere; yes, against Japan, against anybody who plays orthodox war. But when we face total war, when we face Europe, it is a different situation.

As you know, we are expanding into a two-ocean navy. That means just double what we had anticipated. The Surgeon General needs at least 1,000 medical students allocated, earmarked, as a reservoir to give us an influx, a steady 300 young doctors a year, 300 interns, you might say. We hope that you, as key men, as master surgeons, as the heads of these medical centers, will keep us in mind, will tell the student who comes to you and asks for advice about this Navy ensign that Doctor Hook has just explained.

The present law of the draft gives no protection for the freshman or sophomore medical student. The Navy has, may I say, scooped the Army in that we do give an ensign commission to those who have completed the first two years of medical work. With that ensign commission, he is assured of an unmolested naval student career. We need those men and want you to help us on that.

Another thing we need very, very much is more practical training for our young surgeons to perform independent surgical duties under battle conditions. I mean traumatic surgery. Do you understand that traumatic surgery under battle conditions means we have no grand teamwork, no set-up of assistants and all the needs and helps that you in civil life may have and enjoy? We have to face the problem independently, and our young surgeons must be able to make independent decisions, independent operations, and do it immediately.

I am impressed by your program, not this morning particularly, but yesterday and to-morrow. I think we should stress more and more traumatic surgery, horse-and-buggy surgery, crude surgery. That is what we are going to have in this war, crude surgery, horse-and-buggy stuff, horse-and-buggy common sense. Under battle conditions in the Navy, we have to go to chloroform as the only anesthetic that is not explosive—chloroform intravenously, yes, and locally.

I want to say this: Please keep in mind battle conditions in the Navy, independent duty, ships out alone, bombing coming on, all the new horrors of war that Mr. Hitler has shown us, and know that your boy, your son, may be out there. In the Army, you have more cooperation. You have more doctors, more nurses, etc. In the Navy, you have one, two, or three doctors alone on a major unit. He has to function alone. So train him in common sense surgery.

The surgeon general is very anxious for you to know that he is in full accord with maintaining the medical faculties. You must have an uninterrupted flow of medical students, and you people back home teaching must not be called upon to take this front-

line defense. Your job is at home. I hope that you can arrange somehow to see our point—1,000 ensigns, to feed us 300 doctors a year, and we in turn will try to give you everything we can in the way of Navy support. We hope that we can get an auxiliary commission for the older people, so that they, if war comes, may be at least satisfied with the uniform, and knowing that you are doing your bit among civilians, among the home people, as the home fires have to be maintained.

We are not going to do gastrectomies and gallbladder surgery. We are going to do traumatic surgery in this war. Please, help us!

PRESIDENT CHEEVER: The Chair cannot help adding, to what Commander Wilcuts said, the observation that these practical young surgeons that the Navy requires are not going to have time to learn their anatomy on the battleship.

DR. IRVIN ABELL (Louisville, Ky.): What I have to say will not be in discussion of the papers that have been read, but, with your permission, I should like to give to the Association the present status of interns and medical students under the Selective Service Act, if I may do so.

As has been stated here, the need for officers in the Navy and in the Army is an acute one, and, as you know, under the present Selective Service Act there is no provision for the deferment of medical students beyond the first of July. There is practically no chance of any change in the law, and there will be no mass deferments made by the Selective Service Board.

There is a bill at the present time which is before the Military Affairs Committee, known as the Murray Bill, and even though this be reported favorably, it is the impression in Washington that, to use a slang expression, when it gets to the floor of the House and Congress it will not even get to first base because it will be considered as class legislation.

The one thing I wish to tell you is that the Health and Medical Committee yesterday adopted a program which, if it can be implemented, will not require any change in law or any legislation. Commander Wilcuts has told you of the provision of the Navy in commissioning senior and junior students. The Army requested the permission to do the same thing for medical students, and this was declined by the Secretary of War. What the Health and Medical Committee proposes is that all students, when they are accepted by medical schools—that would include all four years—be commissioned as medical cadets and as medical ensigns in the Army and in the Navy. That will give the services actual control of medical students throughout their entire four years. At the end of their graduation, they will then serve a one-year internship in the Army, Navy, or our civilian hospitals, and at the end of that time will serve with the Army, with the Navy, or with the Public Health Service; in other words, one of the three federal services.

We have reason to believe that this will be very favorably considered by the Navy Department, and we have reason to believe that it will not be so favorably considered by the Secretary of War and the General Staff of the Army, unless it can be presented to them in a way that will appeal to them.

In other words, the medical students who are drafted and serve as soldiers, when they have completed their one year in the Army, have fulfilled their duties. If they go back into medical school, at the end of their four years, and at the end of their intern year, they do not feel obligated to continue another year in the Army, and there is no way of requiring them to do so, so their services are lost to the Army.

If this proposal can be implemented, it will give to the Army and the Navy and the military forces something like 3,500 doctors a year. Five thousand graduates at the present time, of which approximately 1,500 are ineligible, either by graduating from schools that are not recognized or because of inability to meet the physical requirements—and a certain percentage of them are women—but there are 3,500 who, under this plan, will automatically come to the military forces of the country. As Colonel Kirk has indicated to you this morning, the fulfillment of the present requirements they are making will practically exhaust the Reserve Corps, so in the four years remaining for the training program it will require somewhere between 4,500 to 9,000 doctors a year to meet those replacements, depending upon the additional million men, which Colonel Kirk mentioned as being possible, and also upon the willingness of those already in the service to take a second year.

This will afford the Army 3,500 a year, or the military forces, if it is possible to get

that. In all of our efforts, since we have had the Health and Medical Committee, this is the first time that a concrete program has been advocated which offers the possibility of being carried out without any legislation, a thing that is extremely difficult to secure in Washington because of the attitude toward doctors and deferments being class legislation. All of the engineers, chemical, technical, mechanical, and whatnot, are possibly equally as important. At least they have been given priority over doctors by the Selective Service Board. So they, too, want deferments, as other groups want deferments. For that reason, it is competently thought in Washington that there will be no mass deferments and no legislation that will permit of deferments.

If the plan which has been mentioned to you can be put into operation, it at least will protect the medical schools so far as the student supply is concerned. It will protect the interns. It will not exempt them, but will permit them to give their service at a time when it will be infinitely of more value to the military forces than as a soldier or a sailor, and at the same time will assure the military forces an annual increment of 3,500.

DR. ELLIOTT CUTLER (Boston, Mass.): Although I may be one of those who believe that America is about as sound asleep regarding her peril as France was a year and a half before hell broke loose over her, I still think we can take some consolation and feel better after the discussions by the servants of the Federal government this morning.

I look back to a trip to visit General Gorgas, in April, 1917, with Doctor Cushing, when the dear old gentleman had to get up ten times in 25 minutes and answer the telephone himself because he did not have a secretary. I look back to the fact that when we arrived in London, in May of 1917, they insisted we go to the American Embassy and get a passport before we could go to France and fight for our country.

Now we have the right to demand better preparation. I know many of you have children. I have three sons who will certainly be mixed up in this war. We have the right to demand proper preparation. We have a right to demand the most effective, stream-lined, or you can use any slang you want to about preparation, both as regards medical preparation and as regards the Army itself.

I hope Colonel Kirk will take back with him the idea that we are thoroughly behind him in his work, that this Association certainly wants to help him, that we realize that the General Staff sometimes does not give to the Medical Department what it wants. We know the months of hard work it took to persuade the General Staff to allow tetanus toxin inoculation of our troops, and we know they are not right in the first line when it comes to decisions.

I was a little disappointed in his discussion about front-line work, that he still stuck to the old adage that the Evacuation Hospital had to be a railhead, because I supposed the motility of modern warfare would leave Evacuation Hospitals anywhere. I recollect being left 25 miles behind a line when we advanced in the last war, and demanding at headquarters that I be moved up with the troops because the sick were dying in the ambulances before they got 25 miles down the line to the hospital, and being told that the big black book of the Medical Department insisted that the Evacuation Hospital had to be in the railhead. I said, "But the troops are going to Berlin, General. Can't I go with them?" He answered: "No, you will stay on the railhead."

I have one or two questions I would like to ask Commander Kirk about the advanced units, because I believe the job of the Medical Department now is to equip properly and standardize the organizations of the unit and not bother too much about professional medical skill. American doctors are as well-educated as anyone in the world, and we will be able to give you all the skill you need, but you must have the tools ready.

The most important thing, in my mind, is a sterilizer. We should have a new stream-lined sterilizer made out of the best modern, light materials, not the heavy apparatus we had in the last war. Somebody should spend a month or two developing a new sterilizer.

The next important thing up the line is power. We ought to have a better thing than the old Delco motor which will run the roentgenologic department and will amply light the field units.

Third, and perhaps almost more important, is a laundry. You cannot run an hospital up the line if you need 12,000 sterile towels a day, unless you can wash them. That was forgotten in the last war. I personally gave up my American laundry in exchange for a French laundry on wheels, which was very much better.

The three things the front units need is a good sterilizer, ample power, and a good laundry. If the medical profession of America is given the tools, they will see this show through very well.

DR. WILLIAM DARRACH (New York, N. Y.): I should like to speak on the treatment of compound fractures but, unfortunately, I have another thought which I want to emphasize, and that is that if we are going to live up to the function of the Medical Department we have to be hard-boiled. The function of the Medical Department is to maintain the fighting strength. If we are going to live up to that, we should concentrate our major efforts on those wounded who can be and may be returned to the fighting forces.

That means that all the special groups, the highly trained and efficient compound fracture surgeons, the maxillary, the head surgeons, the chest surgeons, the belly surgeons, belong not to the main function of the Medical Department, but to their secondary purpose of humanitarian care of those who are severely wounded and who never will go back. We cannot omit handling those people, because part of our duty is to maintain the morale. If we were strictly hard-boiled, we would pay attention only to the lightly wounded. We must pay some attention to the severely wounded, but they should be of secondary importance. Therefore, I think that if the idea that was carried out in a small way, but sufficiently to prove that it can be done, by Joe Davis and Sherbondy and one or two other attempts, whereby the lightly wounded can be handled at the rate of five or six an hour, instead of one case per hour, as most of us were doing on the heavier cases, were really carried out we would find that our Medical Corps work was more efficiently done, and we would restore more men to the fighting forces.

I had one brief experience of almost eight hours of doing this work with the British Clearing Station No. 47. In taking these lightly wounded cases, we could do about four or five an hour there, but the next day the commanding officer came around and said, "I am sorry, but this is not done in the British Army," so we stopped.

Again, in the first corps, there was an excellent plan made for putting an Evacuation Hospital up fairly close, where the lightly wounded could be handled at this rate of rapid production and kept in that area and sent back, but unfortunately for that scheme Armistice came along and spoiled it. I would like to see that scheme put into effect, and that the major function of the Medical Department be recognized as restoring the fighting forces.

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SCIENCE AND HUMAN PROGRESS—I

Thought

THOUGHT is the most important force in the world. Thought gives rise to ideas. Ideas are more permanent than their materialization in visible things. A structure may easily be destroyed, but the idea which gave it birth may become immortal. Civilization, in all its ramifications, is a direct outgrowth of the vast accumulation of ideas. Pure science and its application is a manifestation of that something back of the human mind, which I believe demonstrates the existence of a supreme intelligence.

—A. Cressy Morrison, Transactions of the New York Academy of Sciences, Series II, 2, No. 3, January, 1940.

SKIN GRAFTING AND THE "THREE-QUARTER"-THICKNESS SKIN GRAFT FOR PREVENTION AND CORRECTION OF CICATRICIAL FORMATION*

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THE FREE GRAFTING OF SKIN has a great utility in the general scheme of beneficent surgical therapy, after gross skin and subcutaneous tissue removal, for the purpose of correcting disfiguring blemishes or after gross skin and subcutaneous tissue loss due to traumatic, thermal, or chemical agents. Familiarity with the modern technic of skin grafting will allow the surgical craftsman to largely prevent scarring and cicatricial contraction, as well as to correct such lesions after their final development.

Fundamental to the resurfacing of a large granulating surface is the careful preparation of the granulating area by means of repeatedly changed gauze dressings which are kept saturated with an appropriate antiseptic solution. At intervals, supplementary complete immersion in salt or mild antiseptic solution may also be advantageous.[1] Attention also must be given to the correction of the general deleterious constitutional factors such as anemia, dehydration, alkalosis, hypoproteinemia, and avitaminosis. Finally, the skin graft should not be cut more than and often less than 0.012 of an inch in thickness.[2]

Essential to the correction of various large blemishes and large healed scar contractures is complete release and excision of all limiting scars so that overcorrection is obtained if possible (Fig. 1 a, b, c, d). As an aseptic denuded base follows such excision, a thick graft may be applied with a practical certainty of a complete "take." The "three-quarter"-thickness skin graft—a skin graft cut at a level of from 80 to 90 per cent of the thickness of the skin—in our experience has proved the most efficient graft.[3] The objective of the "three-quarter"-thickness skin graft is directed toward obtaining a graft of such thickness as to assure successful transplantation, leave the donor area capable of spontaneous regeneration and yet of such thickness as to afford adequate protection, minimum contraction, and at the same time match the surrounding skin relatively satisfactorily insofar as texture and color are concerned. The results that have been obtained following the use of the "three-quarter"-thickness skin graft on an aseptic denuded surface very nearly fulfill the preceding criteria.

Material.—For the purpose of making a comparison of the properties and results that may be obtained following the application of the various types of skin grafts, I have available two series of cases. The first and older series[4] of

* Read before the American Surgical Association, White Sulphur Springs, W. Va., April 28, 29, 30, 1941.

171 patients runs up to May, 1936. On 104 of these patients, Thiersch[6] and "split"[1] skin grafts were used which were cut by hand with the large knife. On 59 patients of this series, thin grafts were used to cover a granulating surface, which as a rule was caused by a burn. In 45 patients, thin skin grafts were used to alleviate a cicatrix following a burn. On 67 patients, full-thickness skin grafts[5, 6, 7] were applied to correct a scar or contracture caused by a burn. The second series of 206 patients started January 1, 1938 and runs up to February 1, 1941. On these patients, Thiersch,[6] intermediate[1]

(a) (b) (c) (d)

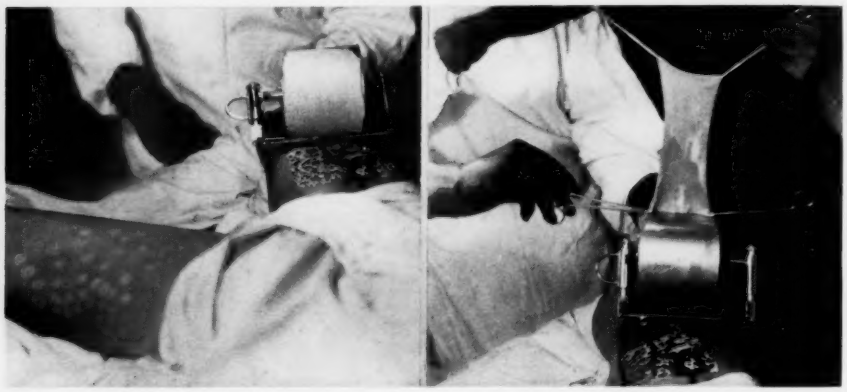
FIG. 1.—(a) and (b) Medial and lateral views of a nearly healed cicatrix of the popliteal space. In such a case, the scar has to be cross-cut. The uneven scarred areas are removed. The leg is completely extended as the various bands of scar tissue are removed. In this patient, two drums of skin from the abdomen were removed and applied to the leg. The thickness was about 0.018 of an inch. It was judged that this boy's skin was about 0.022 of an inch thick. (c) and (d) Result after several months.

and the "three-quarter"-thickness skin grafts, as cut with the dermatome,* were applied (Fig. 2 a, b). The reason for eliminating the patients operated upon from May, 1936 to January, 1938, is that our technic and results in no way changed during this interval, until a new technic[2] was adapted in January, 1938. That is, a stationary period had been reached.

Comparison of Properties and Results Obtained after Thin and Superficial Intermediate Skin Grafts as Cut with the Large Knife and the Dermatome when Applied to a Granulating Surface.—The most striking point noted in comparison with the first and last series of patients alluded to above, upon whom thin skin grafts were placed, was that in the latter series an average of 357 sq. cm. of skin was applied at one sitting, while in the first series the average was 89.6 sq. cm.

* The dermatome alluded to and shown in Fig. 2 is one conceived by the author and developed and designed with the joint mechanical aid of Professor George J. Hood, Professor of Mechanical Engineering at the University of Kansas.

In the early series, 59 patients who had one or more granulating areas were skin grafted with thin-cut skin grafts; 93 areas were skin grafted at 80 operations. Of 93 grafts applied to cover a granulating surface, in 43, there occurred a "take" of 90 per cent, which may be considered as practically perfect; in 13, there occurred a "take" of over 80 per cent, which may be considered as "good," and in 30 there occurred a "take" of over 70 per cent, which was usually sufficient, so that further grafting to the granulating surface was not necessary. In eight, the loss ranged from 30 per cent to the entire graft. The usual cause of loss was infection developing beneath the graft.



(a) (b)

FIG. 2.—(a) A "three-quarter"-thickness skin graft is being removed from the inner side of the thigh with the dermatome. The skin graft is attached to the drum of the dermatome after it is almost entirely cut. (b) Removal of the skin from the drum. This graft is 4x8 inches in size. It was taken from the thigh of a young woman, age 24, and was cut 0.020 of an inch thick. It was placed on a large denuded aseptic area on the neck.

In the second series of 70 patients upon whom thin skin grafts, cut by the dermatome, were applied, an average area of 357 sq. cm. was covered at one sitting. From three patients, six drums of skin were removed at one operation. Eighty-one operations were performed.

An average of 80 per cent of skin "took" in the 81 operations. After four operations, not more than 25 per cent of the skin "took." After six operations, most of the skin was lost due to infection developing beneath the graft.

Early in the first series, it was noted that in patients upon whom thin skin grafts were applied to a granulating surface, if the hemoglobin was below 65 per cent of normal the chance of a successful "take" was decreased from one-third to one-half because of the greater tendency for the graft to be destroyed by infection. Later, in the second series, the deleterious effects of an unexplained temperature of over 101° F., an improper electrolyte balance, a hypoproteinemia, or an avitaminosis, insofar as a good "take" was concerned, were noted.

As a general rule, thin skin grafts were applied to granulating surfaces with the idea of obtaining early coverage to lessen functional disability about such locations as the hands and fingers, or to get earlier healing of the granulating area so the period of hospitalization could be reduced to a minimum

(Fig. 3 a, b). In some cases, however, even after complete resurfacing, especially when the denudation had occurred about a joint, a contracture developed in the bed beneath the graft which later had to be corrected by cross-

(a) (b)

FIG. 3.—A large granulating area on the leg caused by a burn. On the inner side, the area runs up above the level of the lower end of the femur. The skin graft was cut 0.012 of an inch in thickness. A good "take" was obtained so that later skin grafting after the first period in the hospital was not necessary. (b) Result one year later. By this time, a good subcutaneous tissue had formed. The graft had the appearance and pliability of normal skin. There is no tendency to ulceration. The scarring between the graft and the normal skin is minimal.

cutting the cicatrix and applying a "three-quarter"-thickness skin graft on the resultant aseptic denuded surface.

In the second series, it was noted that when the condition of the patient was good and the condition of the granulating surface was above reproach, one could apply, in the adult, a superficial intermediate dermatome-cut skin graft of about 0.012 of an inch in thickness, *i.e.*, a skin graft somewhat thicker than the so-called Thiersch graft (about 0.008 of an inch in thickness) with the idea of preventing some of the subsequent contracture which is likely to

occur after the application of a thin skin graft. This idea, it was observed, could not be carried too far, however, as the chances of obtaining a good "take" were diminished proportional to the increased thickness of the graft when it was applied to a granulating surface. This was found to be true, especially if there was any question concerning the cleanliness of the granulating recipient area or the general condition of the patient.

Caution was found to be necessary when using the dermatome-cut[2] skin graft so the graft would not be too thick. It must be remembered that the most important factor in grafting with thin skin on a granulating surface is to get a good "take" and early healing.

No new factor was found to be involved, and there was no essential difference between the superficial intermediate calibrated skin grafts as cut with the dermatome and those cut by hand save that one could select a predetermined thickness and cut the graft with the dermatome at a uniform level. It was found that a graft of much larger size could be taken from locations not previously available when the dermatome was used. Satisfactory skin grafts were often obtained from the pectoral, scapular, lumbar, the posterior gluteal regions, from relaxed, pendulous abdomens, from babies, and even over the ribs when the patient was not too emaciated. As a rule, it was found that to take a satisfactory skin graft from the preceding regions with the skin-graft knife was very difficult or impossible. The increased area of skin available allowed us, in the latter series of patients, to successfully skin graft many difficult areas in a fewer number of operations than was possible in the first series of patients. For example, the type of patient with a large denuded surface covering both thighs and legs, where most of the remaining skin was on an emaciated trunk, usually succumbed in the first series because of our inability, at the proper time, to get sufficient skin to cover the denuded areas. Later, the lives of several such patients undoubtedly were saved because it was possible to quickly remove from four to six drums of skin at one sitting, *i.e.*, from 325 to 488 sq. cm. of skin. Moreover, after a period of from three to four weeks, it was found possible to remove a similar quantity of skin from the same donor site. In the latter series of patients, from whom thin skin grafts were removed with the dermatome, the number of operations required to resurface the granulating areas was reduced by about 50 per cent (first series, 59 patients, 80 operations; second series, 70 patients, 81 operations). Also, the operating time was considerably reduced—a factor of some value when the patient was not in the best of condition.

Thin Skin Grafts on Aseptic Denuded Surfaces.—On certain surfaces, where contracture is not likely to occur because the bony framework beneath the area prevents contracture or where overcorrection may be made as about the eyelids or eye socket, it is often advisable to use a comparatively thin skin graft on what is at least a relatively aseptic denuded surface. Provided one uses, with efficiency, the known prerequisites such as good hemostasis, adequate pressure, and fixation, it has long been known that thin skin grafts on such a surface usually "take" nearly 100 per cent.

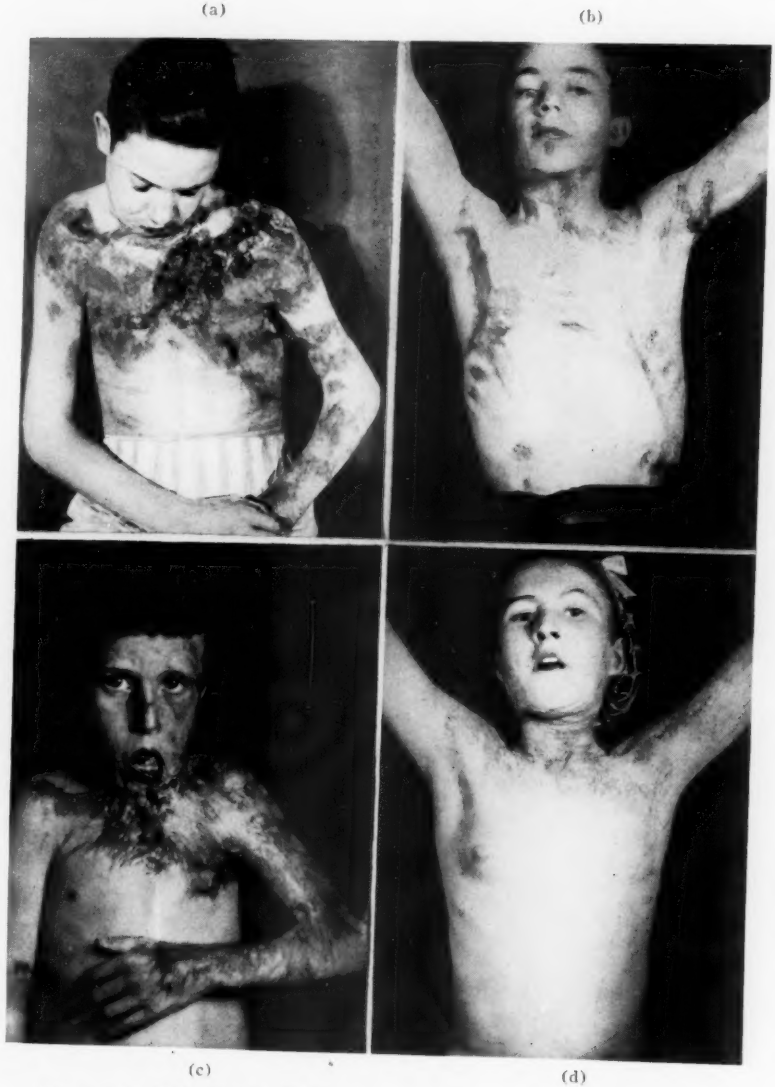


FIG. 4.—(a) This boy had suffered a very severe burn of the neck, anterior and lateral chest, and the left arm. The correction of this case required three operations. At the first operation, the granulating area was covered. At the other two operations, the contractures were released. At the two last operations, six drums of skin were removed from the patient at each sitting. The grafts were taken from the thigh, lower abdomen, right and left buttocks, and from the back. (b) Final result. He still has slight scarred ridges which, probably, after a few years should be alleviated by excision and careful resuturing. His functional result now is good. The first grafts were cut 0.010 of an inch thick to cover the granulating area. Later, we covered the aseptic denuded surface with "three-quarter"-thickness skin grafts which were cut 0.020 of an inch in thickness. (c) Example of a very severe cicatricial contracture of the neck and arm which was corrected by means of "three-quarter"-thickness skin grafts, of about 0.016 of an inch in thickness, in three operations. This case was published in Surg., Gynec., and Obstet., 69, 789, 1939 (Fig. 19 a), but since that time a small operation has been performed beneath the chin to eliminate a defect in that region. The first photograph was taken October 18, 1936, when she was age eight. (d) Final result, April 20, 1941 (age 13). Both the functional and cosmetic results are good.

In the early series, on 45 patients, thin grafts of one type or another were applied to a comparatively aseptic, freshly denuded surface to alleviate a scar, a contracture, or to line a cavity. In this group, an average area of 29.5 sq. cm. was covered. To give the amount of correction deemed necessary, 58 operations were required. The final average contracture was estimated at 37 per cent.

In the latter series, unless the indication was definite for a very thin graft, our tendency was to use at least a deep intermediate graft or a "three-quarter"-thickness skin graft for the purpose of covering aseptic denuded surfaces. In the second series, therefore, very few really thin skin grafts were used. Usually, intermediate and so-called "three-quarter"-thickness skin grafts were judged to be the type of skin most applicable.

Although, in many instances, it was found that one could cut the thin graft by hand just as satisfactorily or even in some instances more so than one could cut with the dermatome, when it was deemed desirable to vary the thickness at will, depending upon the region to which the graft was to be applied and the lesion to be corrected, or when a large perfect sheet of skin was advantageous, the dermatome-cut thin graft was used. Thus, when it proved desirable for various lesions in different locations to lean toward thinness or thickness, as indicated, the machine-cut graft proved to have definite advantages. The ability to call one's "shots," so to speak, was especially valuable when removing skin from babies, children, and from such areas as the inner side of the thigh in certain fat, thin-skinned women.

The Full-Thickness Skin Graft Versus *the "Three-Quarter"-Thickness Skin Graft to Cover Aseptic Denuded Surfaces.*—A comparison of the results of the full-thickness skin graft as cut with the scalpel and the "three-quarter"-thickness skin as cut with the dermatome brings out some rather striking differences in properties.

In the first series of cases, full-thickness skin grafts were used upon 67 patients who suffered from scars or contractures due to burns. After excision, the aseptic denuded surfaces averaging 26.4 sq. cm. were covered with 155 full-thickness skin grafts. Ninety-one operations were required to obtain the maximum correction deemed possible. Of the 155 full-thickness skin grafts, 130 showed from 90 to 95 per cent "takes." At that time, although the grafts showed in many instances some superficial blistering or small areas of necrosis, if the majority of the graft "took" the "take" was listed as good. This meant that the "take" was sufficient to largely cover the denuded area. In three instances, the whole graft was lost. In 25 instances, the loss was partial and ranged from 10 to 90 per cent. The causes of the loss were judged to be infection of all or some part of the grafted area in 12 cases, lack of adequate pressure in 12, too much pressure in one, blood clot in two, and improper splinting, which allowed muscular movement beneath the graft, in one. Provided a good "take" occurred, the most important influence on the functional result was the final amount of contracture of the grafted area. The subsequent contracture of these full-thickness skin grafts averaged about 17

per cent. In other words, when the full-thickness skin graft was applied to an aseptic, denuded surface about a 20 per cent chance was run of not getting a sufficient "take" to correct a contracture, and in from 40 to 50 per cent the areas of blistering and superficial necrosis compromised the cosmetic appearance sufficiently to make the graft of questionable value when applied to such exposed areas as the cheek or neck. A good "take" with a full-thickness skin graft on an uneven concave surface, such as the axilla or neck or cheek, was particularly uncertain.

In the second series, either deep intermediate or "three-quarter"-thickness skin grafts were applied to aseptic denuded surfaces. In 137 patients, the denuded area averaged 188 sq. cm. The largest areas covered—four cases—were 488 sq. cm.—six drums (4x8 inches) of skin (Fig. 4 a, b, c, d). The percentage of "take" averaged 96. On an average, the percentage of contracture was somewhat less than after the use of a full-thickness skin graft. This would seem, at first glance, to be paradoxical. It is probably due to the rapidity and completeness of take usually obtained after the use of the "three-quarter"-thickness skin graft. The underlying anatomy of the region and the type of bed upon which a skin graft was placed, influenced the degree of contracture. In certain situations, as on the anterior neck, these grafts, as a rule, contracted one-third or more.

With the "three-quarter"-thickness skin graft, as cut with the dermatome, it was found that if properly cut, provided other factors such as proper fixation, tension, hemostasis, pressure, and a clean field were obtained, the chances of failure to "take" were nearly eliminated. Because of the certainty of "take," the magnitude of the reconstruction could be extended to limits not advisable previously. Difficult areas to graft with thick grafts, such as the lateral cheek, the neck, and the axilla (Fig. 5 a, b), and dorsum of the hand (Fig. 5 c, d) became acceptable cases in which successful repair was to be expected and not just hoped for.

The protection given also compared favorably with that given by the full-thickness skin graft after a good "take" was obtained. For example, adequate protection was given over the palm and back of the hand. It will be noted that the number of times two skin grafting operations were required, when the "three-quarter"-thickness skin graft was used, was reduced over those required, when the full-thickness skin graft was used, more than one-half. When full-thickness skin grafts were used on 67 patients, 91 operations were required. When the "three-quarter"-thickness skin graft was used in 183 patients, 203 operations were required. This was due to two reasons, namely, the quantity of skin that could be removed was greater and the percentage of "take" was higher when the "three-quarter"-thickness skin grafts were selected (Fig. 6 a, b, c, d).

The "three-quarter"-thickness skin graft also had the advantage that it could be taken from almost any part of the body (chest, abdomen, thigh, buttocks, and back). On babies, small children, and the emaciated, it was possible to easily obtain the proper amount and thickness of skin.

The fact that this type of graft showed very little blistering or areas of necrosis caused the final appearance to approach that of normal skin. The appearance was as good as that of a full-thickness graft after a perfect "take." The fact that the donor area did not have to be sutured and that it healed in from 14 to 18 days also was in its favor.

Occasionally (in about 5 per cent of the patients), after removal of a "three-quarter"-thickness skin graft, a tendency to heavy scarring of the donor area developed. In practically all instances, control of this situation was given by excision of the scar when the heavy scarring was at one side of the donor area, or if distributed diffusely, proper roentgenotherapy was advantageous.

To recapitulate, the "three-quarter"-thickness skin graft, as cut with the dermatome, is comparatively certain to "take." The new graft shows practically no blistering or areas of necrosis. The ultimate contraction is reduced to a minimum. Good protection is offered. The appearance, as a rule, approaches that of normal skin. The donor area heals quickly. The postoperative period of care is relatively short. Finally, as a rule, the usual run of lesions may be corrected in one operation.

TECHNIC

The following operative and postoperative technic has become more or less routine:

Thin Skin Graft Applied to a Granulating Surface.—The skin graft (0.008 to 0.012 of an inch in thickness) is laid on the undisturbed granulating bed. The edges of the skin graft are stitched with running silk suture to the skin, circumferentially. When more than one graft is necessary to cover the surface, one graft is stitched to the other in quilt-fashion (Fig. 7 a, b, c). Here and there small holes are then cut in the graft in pie-crust fashion. A thick roller gauze dressing saturated in boric acid solution is then snugly applied. Above this, cotton pads are laid to hold the moisture. If necessary, a splint is used to prevent movement. This gauze dressing is kept saturated for four days.

On the fourth day, the first dressing is removed and reapplied. The stitches are removed within five days. The moist dressings are then changed daily until the graft is healed—a period of from 12 to 14 days after application.

"Three-Quarter"-Thickness Skin Graft Applied to a Relatively Aseptic Denuded Area.—In this situation, one either has a clean field because the lesion is a healed one or else centrally located, or there may be present an old ulcer with a thick fibrotic base. In the former cases, the cicatrix is cross-cut and removed, as indicated. In the latter case, the surrounding scar is circumscribed with a scalpel within the normal subcutaneous level without touching or cutting into the base of the ulcer. That is, the unhealed area is excised deeply below its fibrotic base. This gives a relatively aseptic denuded base. The "three-quarter"-thickness skin graft is now stitched to the skin circum-

FIG. 5.—(a) An axillary contracture corrected, in one operation, by the application of "three-quarter"-thickness skin graft cut 0.016 of an inch in thickness. The graft was removed from the abdomen. (b) Result one month later. (c) Granulating wound of the hand corrected by the application of a "three-quarter"-thickness skin graft cut 0.020 of an inch in thickness. The graft was removed from the abdomen. The scar and granulating area was excised by cutting beneath the granulating bed. This patient should have been grafted within the first three or four weeks after the injury instead of five months, as was the case here, if the maximal functional preservation of the extensor tendons was to be obtained. (d) Final result.

FIG. 6.—(a) A large cancerous ulcer which developed in a cicatrix in the popliteal space, several years after the infliction of the original burn. This ulcer was excised, radically, along with the scar, down to the muscle layer. Two 4x8 drums of "three-quarter"-thickness skin, about 0.022 of an inch in thickness, were removed and applied over the large aseptic denuded area in the popliteal space. (b) Result one month later. Corrected in one operation. (c) An old cicatricial contracture of the groin which prevented complete extension of the thigh. To correct this lesion, all of the scar in the groin was excised so the leg could be extended. "Three-quarter"-thickness skin grafts from the buttocks and the back, cut about 0.020 of an inch in thickness, were applied. (d) Final result one year later. Two and one-half drums of skin were applied. (This patient was operated upon by my associate, Dr. N. B. Soderberg.)

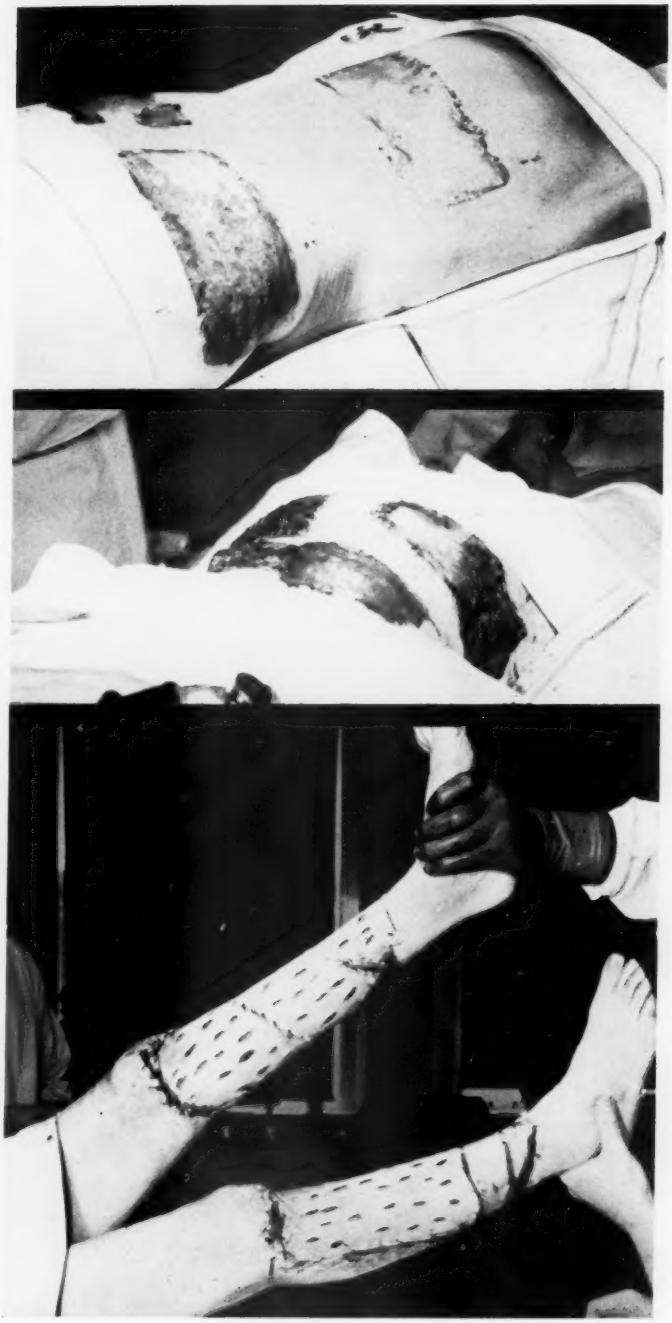


FIG. 7.—From this patient, six drums of skin—a total of 488 sq. cm.—cut 0.010 of an inch in thickness, were removed from the trunk. Three drums were taken from the back and three from the abdomen and lower chest. (a) Shows back view after removal of three drums of skin. (b) Shows front view after removal of three drums of skin. The skin was stitched over the granulating areas which completely encircled the whole of the circumference of both legs. (c) The skin graft was stitched over the granulating area in quilt fashion. The graft was perforated in pie-crust fashion to promote drainage. This photograph was taken immediately following completion of the operation. Some idea of the technic of the operation is depicted.

ferentially, over the aseptic denuded area with a running silk suture. When more than one graft is used, each graft is sutured to the adjacent one. When the graft is placed elsewhere than on the face, usually, here and there small puncture holes are made to promote drainage. When the graft is applied to the face for cosmetic reasons, the puncture holes are dispensed with. Next to the graft is laid gauze treated with 5 per cent bismuth tribromphenate in petrolatum. Next to this are laid about two layers of wet gauze. An adequate number of wet (saline), fine marine sponges are next applied. Above this, a cotton pad is laid. The whole dressing is then securely bandaged in place. If necessary, a plaster encasement or a splint is applied to assure adequate fixation. This dressing is not changed for a week or ten days because there is little or no danger of infection. The dressing is not kept wet. It is allowed to dry so that the sponges will harden and form a type of splint. When the first dressing is removed, the stitches are removed. The graft is dressed with moist dressings until healed. This usually occurs within a period of a week. This dressing is no different than the sponge dressing originally described by Blair,[7] and used by him as a dressing after the application of full-thickness skin grafts.

Skin Graft versus Skin-Flap.—When the surgeon is considering resurfacing many areas, not only do the advantages and disadvantages of the most appropriate skin grafts have to be weighed but also do the advantages and disadvantages in certain instances of a skin graft *versus* a skin-flap have to be considered.

In general, a skin-flap may have the following advantages: A fairly high resistance to infection; some thickness for the purpose of filling a contoural defect; little subsequent contracture; trauma is fairly well withstood; the skin is soft and pliable; and the color is normal for the area from which the flap is removed.

One of the main disadvantages of the tubed skin-flap is the number of operations entailed in the transfer. In some instances, considerable damage is inflicted on the donor area.

For the building of organs requiring thickness, for filling a depression in the soft tissues (Fig. 8 a, b); for building a part requiring two soft pliable epithelial surfaces and some thickness such as the nose, the cheek, and the lip; and as a direct covering for bone (Fig. 8 c, d) or cartilage, the pedicled-flap has no substitute.

To correct wide areas that are denuded, wide scars, and blemishes or cicatricial contractures, unless a sliding flap from the immediate region can be utilized, generally a skin graft of one type or another is the preferable material for coverage. That is, where simple surface epithelial covering is the only indication, in my opinion, the proper type of skin graft, as a rule, will give the most acceptable and efficient result. For practically all contractures about the axilla, elbow, wrist, hand, groin or popliteal space, I believe the application of the proper skin graft is preferable to a skin-flap. As a rule, proper resurfacing of a denuded area may be obtained in one operation. This

fact allows this type of reparative surgery, as regards the length of time required for convalescence, to compare favorably with other major surgical operations.

SUMMARY

(1) The results obtained with skin grafts, as cut with the large knife and scalpel, are compared with the results obtained with skin grafts cut by a dermatome, when applied to both granulating (usually caused by a burn) and aseptic denuded surfaces resulting from excision of a scar, large blemish or contracture.

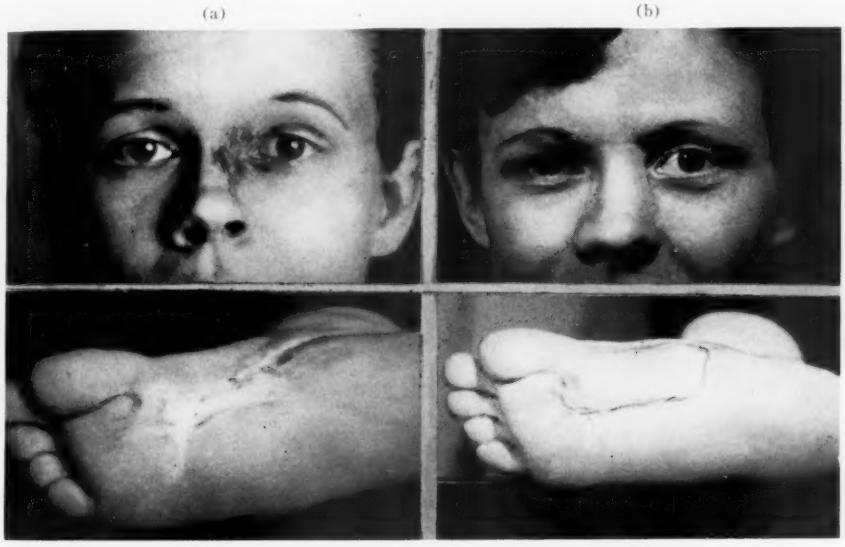


FIG. 8.—(a) This girl had been treated somewhat too thoroughly by radium in her childhood days for an hemangioma. Considerable scarring resulted with a depression along the lateal side of the nose. A flap from the forehead was turned down to fill out the contour of the nose. (b) Final result, 18 months later. (c) Example of a scar on the bottom of the foot which was attached directly to the underlying bony tissues. In such a case, it was considered that a skin-flap was much more applicable because of the trauma which the foot would have to withstand. (d) Final result, three months after transfer of a flap from the opposite calf.

(2) The advantages of the "three-quarter"-thickness skin graft, as cut with a dermatome, for the coverage of an aseptic denuded surface is stressed.

(3) The operative and postoperative technic used in applying thin grafts to a granulating base and the "three-quarter"-thickness skin graft to a relatively aseptic denuded base is briefly described.

(4) An opinion is ventured concerning the position of skin grafts with relationship of skin-flaps where a simple epithelial coverage is the only indication.

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DISCUSSION.—DR. ROBERT H. IVY (Philadelphia, Pa.): I fully realize that there are others here who are far more competent to discuss this paper than I am, and Doctor Padgett's results present very few loopholes for discussion.

In presenting the dermatome, he has undoubtedly made one of the lasting contributions to plastic surgery, and his report clearly demonstrates that he is able to obtain results with it that are superior to freehand methods of skin grafting. In the hands of those practiced in its use, the dermatome will permit the cutting of the skin grafts of the dimension and controlled thicknesses possible to achieve in no other way. But, like everything else, its use has to be mastered.

Nothing looks simpler to one first observing the procedure than the apparently mechanical ease with which the practiced hand removes the graft by means of the dermatome. On the other hand, if the occasional user relies too much upon the mechanical features of the instrument and overlooks certain little details, such as proper consistence of the cement, application of the cylinder to the skin surface, *etc.*, he will show many disappointments. Again, just as much, if not more, of the success of the skin graft depends upon its application to the raw area and the after-care as upon the actual cutting.

It has long been generally recognized that the thicker the successful skin graft the better the result as to pliability, minimum contraction, and appearance. Doctor Padgett's chief contribution has been to evolve a technic which permits the use of the thickest uniform sheet of skin with the greatest percentage of takes.

Regarding the "three-quarter-thickness," I feel that this must be an aim to have in mind, rather than an actuality in every case, because there is no way of determining beforehand in every case just how thick the skin of an individual is, and therefore no way of knowing that setting the dermatome to cut off a given thickness will in that particular person take half the thickness of the skin, or three-quarters, or the full thickness.

My chief point in this discussion is that in this work we should stress the side of the individual skill and experience and not be carried away by overemphasis on the machine. I know Doctor Padgett does not do that, but others who have only occasionally had recourse to skin grafting might get the impression that all the difficulties about the art are now ended.

One of the chief things which I hope will be accomplished by these advances in technic is the elimination of the use of the small pinch grafts for covering raw areas on exposed parts of the body. As more and more surgeons become expert in the cutting and application of the large razor grafts, I feel sure that other easy but less satisfactory methods will be abandoned.

Doctor Padgett, in his original paper, which he did not mention, spoke about pedicle-flaps *versus* free skin grafts for covering raw surfaces. I feel that with movable parts, without a firm underlying base, such as the neck, axilla, *etc.*, personally I have had much better results with the Z-flap or two pedicle-flaps, rather than free grafts.

DR. VILRAY P. BLAIR (St. Louis, Mo.): Doctor Padgett also asked me to say something about this, but the others did not leave anything to say. I think the dermatome is one of the very, very few really new things that are put into the mechanics of surgery. The combination of a rocking plane and glue is something new.

Doctor Padgett compared his three-quarter graft to a full-thickness graft. I think,

probably, it is a compromise there between the amount of derma taken and the smoothness; that is, it gives enough derma to prevent contraction, and it takes better because it is more smooth and cleanly cut, and any clean-cut wound heals better than a roughly cut wound. You can hardly get that smooth cutting with a scalpel.

I don't know if I understood right or not about the appearance of those grafts. I never have the least idea what color a graft is going to be when it heals, no matter how it is cut, except that I am willing to bet it isn't going to be the right color.

DR. JEROME P. WEBSTER (New York, N. Y.): Doctor Padgett has definitely added a new principle to the procedure of removing large areas of skin from the body. Taking one instrument, putting a rubber cement on it and placing it on the skin, and then drawing it up and cutting it off with a knife gives an opportunity of cutting a graft which is of uniform thickness, and that is something which we may not be able to obtain by the ordinary cutting of a graft with a large knife. The edges on the thigh, or if it is attempted from the abdomen or back, are apt to be thin, and the rounded portion in the center is apt to be thicker.

I think one of the main advantages of the dermatome over freehand cutting is that you increase the number of donor areas. Ordinarily the free graft was taken from the thigh, as the most satisfactory site from which you could take the largest grafts. I have seen general surgeons take much larger grafts by freehand from the thigh than you can take from one drum of the dermatome, but that is largely only when you have a rather stout woman and you can take the full length from the knee up to the trochanter.

The big advantage of taking from the abdomen, the chest, or the back, to me, is that the patient donor area heals more rapidly than it does from the thigh, because you do not have the hypostatic congestion in getting up. The donor area is apt to have blood come out underneath the new epithelium; and for the same reason you are able to get your patient up much earlier if you take the graft from the trunk than if you take it from the thigh.

Another thing that must be considered is that the thighs or lower legs nowadays are more exposed in bathing suits and in the shorts that are worn, so that that does not give deforming scars.

To me the three-quarter-thickness graft, as a name, is illogical, as Doctor Ivy said. I think the thick skin graft is much more applicable.

I am, frankly, always skeptical about statistics, and I wish that, instead of giving the time from his early cases until 1936 and then jumping two years, he had given the years from 1936 until the time he used his dermatome, because, as he said, his practice was stationary, and I think those years for statistics will be much more applicable in comparison with the period used for the dermatome.

I do want to say that with practice I think the general surgeon is going to be able to take skin grafts in large areas to cover defects, either of burns, contractures, or operative defects for malignancy on the exterior of the body, which will give him much better success than if he only occasionally tries a free skin graft by hand.

TREATMENT OF COMPOUND INJURIES BY THE CLOSED PLASTER ENCASEMENT METHOD*

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AND

CALVIN M. SMYTH, JR., M.D.

PHILADELPHIA, PA.

IN 1935, the authors[1] presented a paper on the treatment of compound fractures before the American Surgical Association, in which we reported our experience with the closed plaster encasement method. We first began using this form of treatment in 1927, and at the time of the 1935 report had employed it in something over 100 cases. Although the results had been uniformly good and, in our opinion, superior to those obtained with the older methods, we were unable to rouse much interest in the procedure. For some reason, which has never been clear, surgeons everywhere have been loath to adopt, or even try, this plan of treatment in spite of the excellent results which had been obtained by the few who advocated it.

During the recent Civil War in Spain, with the bombing of the civilian population of metropolitan centers from the air, an unprecedented opportunity arose for a great mass clinical trial of this method of treating compound injuries. Trueta, who was at that time in charge of the Base Hospital at Barcelona, had had previous experience with the plaster encasement method in civil and industrial practice, and at once appreciated its value in war casualties, and it soon became the accepted procedure in Spain. He (Trueta[2]) has summarized his experience in a short but excellent monograph in which he reports on 1,073 personal cases, with good results in 976, bad results in 91, and six deaths. Results such as these are not obtainable with any method with which we are familiar. Eloesser,[3] who took a surgical unit to Spain, also had an opportunity to treat a great number of compound injuries and reports in a recent article that he found the plaster encasement method to be everything that had been claimed for it. In a personal communication, Doctor Eloesser states that one thing that impressed him tremendously, was the fact that recent graduates, with but little training and experience, were able to master the technic quickly. This point was stressed in our paper previously referred to.

In the present war in Europe, the same problems arose as in the Spanish Civil War. As a result of air raids, a great number of compound injuries required treatment. It at once became apparent to the British that the plaster encasement method had most to offer. In support of this statement, we have the testimony of Dr. Philip Wilson who reported his personal experience with 55 cases, and that of Mr. Leonard Broster,[4] Chief Surgeon to Charing

* Read by title before the American Surgical Association, White Sulphur Springs, W. Va., April 28, 29, 30, 1941.

Cross Hospital, London. To quote Doctor Wilson: "The method has certainly taken England by storm." Mr. Hey Groves in his foreword to Trueta's monograph gives testimony regarding his conversion and says: "I must confess to having originally had a deep-seated prejudice against the closed method of treating fractures and the encasement of wounded limbs in plaster." And again: "It is literally the case that this method must be seen to be believed." We cannot refrain from quoting further from the concluding paragraph of Mr. Hey Groves' foreword because we agree with him so completely; he states: "I am very much afraid that many of those who will be called upon to treat air raid casualties will, by prejudice and education, be hostile to the methods here described. If there is anything I can say by which their skepticism may be removed and a fair trial given to methods which I believe to be of inestimable value, my little effort will be amply rewarded and I shall make some amends for the tardiness of my own conversion."

In the face of such testimony, it is discouraging to acknowledge that, in this country, there has, to date, been no significant change of attitude on the part of most surgeons. In a recent number of Surgical Clinics of North America, which was devoted to the treatment of fractures, almost without exception the contributors, in discussing compound fractures, advocated either immediate closure or loose or half closure, with drainage by leakage. The indications for the first of these are extremely limited, and any attempt to extend them is to invite disaster; of the latter, probably the least said the better, for it has but very little to recommend it. At no place in this symposium is the plaster encasement method mentioned.

In a recent report by Coller and Farris,[5] some very definite criticisms are brought out. These emanated principally from the French, who stated that in refugees arriving in France after having been treated in Spain by the plaster encasement method, many of the fractures were badly or not at all reduced, projectiles were often still present in the wound and the encasements were often in bad condition. We submit that the first two of these statements do not constitute legitimate criticism of the method, but of bad surgery; in regard to the third, the obvious answer is that it is too bad that the encasements were in bad condition but many of these men had walked on these plaster cases over icy roads or no roads at all, some of them for more than 100 miles. What other method, may we ask, would have permitted this?

During the six years since our last report, we have continued to employ the plaster encasement method in selected cases. We do not employ or recommend its use in every compound fracture. It is not the best method in fractures associated with stripping of large areas of skin, or in fractures associated with extensive damage to the circulation. It is in this latter group that gas infection is most likely to develop. We feel that we can recognize these cases, and offer in evidence of this the fact that in no case treated by us with plaster encasement did gas gangrene occur. In our previous paper, we advised against the use of the method in fractures of the

femur. This was because we felt that proper immobilization could not be obtained by plaster. With the use of "half-pin" traction and extension this objection has been overcome. We are also hesitating less to apply plates, screws, wires, and other direct fixation in these cases.

The technic has remained much the same and consists essentially of: (1) Extensive débridement. (2) Flushing with ether. (3) Reduction and retention of the fracture by whatever method necessary. (4) Packing with vaselined gauze. (5) Complete circular encasement in plaster. (6) Prophylactic administration of combined gas gangrene-tetanus antiserum. (7) No dressings for four weeks, at which time the packing is removed and if conditions are favorable skin grafts are applied to the granulating wound. (8) Reapplication of plaster and no further dressing until healing is complete.

Among the objections that have been made to this method is the odor. It is true that this is offensive, but not so much to the patient as to the doctors, nurses, and other patients. As no one ever dies of a bad smell this would seem to be a minor matter. We have noticed, however, that since we have employed skin-tight plaster, the odor is much less than in the days when we were padding the encasements.

Regarding chemotherapy, we are unable to speak with authority derived from experience because we have had none. Our earlier cases were all in the presulfonamide era. Since our results were good without the introduction of bacteriostatic substances, we have not as yet become convinced that their use is necessary. Conflicting opinions on this matter have been expressed by Key,[6] and Meleney.[7] Wilson[8] has stated that he saw cases treated with and without the aid of the sulfonamide drugs and had seen no difference in the results. We have an open mind on this subject, and we are quite willing to admit that, particularly, if the initial débridement has been inadequate, chemotherapy may offer additional protection. It is our feeling that here, as in so many other situations, there is a tendency to regard such things as substitutes for rather than adjuncts to good surgery.

Our experience with the plaster encasement method is summarized in accompanying tables. A total of 252 cases have been treated, with five deaths. One of these patients died of tetanus. The patient was a child, age 7, who had been injured in a barnyard. The fracture was of the radius and ulna. Tetanus antiserum was administered prophylactically. No case of gas gangrene developed.

The fatal cases were as follows:

Case 1.—Compound fracture of tibia and associated fracture of the skull, with rapidly developing compression. Death 24 hours after operation.

Case 2.—Compound fracture of tibia and fibula. Good immediate result but developed lobar pneumonia and died 41 days after injury.

Case 3.—Compound fractures of tibia, fibula, and ulna. Severe shock. Good immediate result. First dressing made at end of four weeks. Death from sepsis due to osteomyelitis and cellulitis on fifty-fourth day after injury.

Case 4.—Child, age seven. Compound fracture of radius and ulna sus-

tained in a barnyard accident. Death from tetanus on the seventh day after injury.

Case 5.—Compound fracture of tibia and fibula. Associated head injury and chronic heart disease. Became pulseless on operating table but rallied after transfusion. Developed pneumonia on twenty-sixth postoperative day and died. No complications at fracture site.

TABLE I

CASES TREATED BY THE PLASTER ENCASEMENT METHOD
1935–1940

Bone Involved	No. of Cases	Complications	Results: Good	Fair	Poor	Death
Femur	8	Osteomyelitis —1 Wound infection —1	5	3	0	0
Tibia alone	23	Ankylosis of knee —1 Osteomyelitis —1	18	5	0	0
Fibula alone	6	None	6	0	0	0
Tibia and fibula	46	Delayed union —1 Empyema —1 Osteomyelitis —1 Amputation of foot—1	34	7	1	4
Humerus	7	Stiff elbow —1	5	1	1	0
Ulna alone	6	None	6	0	0	0
Radius alone	5	None	5	0	0	0
Radius and ulna	14	Malunion —1 Tetanus —1	12	1	0	1
Other bones	15	Atelectasis —1	15	0	0	0
Totals	130		106	17	2	5

We do not wish to give the impression that these are the only deaths that we have had in compound fractures. These are deaths in cases treated by the plaster encasement method. There were several deaths, amputations, and cases of gas gangrene in cases which were treated by other methods for

TABLE II

CASES TREATED BY INTERNAL FIXATION

Bone Involved	No. of Cases	Type of Fixation
Femur	3	Wire —1 Plate —2
Tibia and fibula	11	Wire —6 Plate —5
Radius and ulna	6	Wire —4 Plate —2
Totals	20	Wire —11 Plate— 9

various reasons. In practically all of these there were serious associated injuries.

In view of the results obtained by all those who have given this method a fair trial, we submit that the treatment of compound injuries by the plaster encasement method is deserving of a wider acceptance than it has hitherto enjoyed. Experience has demonstrated that the objections to the method have not been borne out after mass clinical trial. In military surgery, it offers a plan which enables us to give adequate consideration to the wound, to the fracture, and to the safe transportation of the injured man. It demands less of the surgeon, and in view of the shortage of qualified men this is of major importance in time of war.

TABLE III

CASES TREATED BY FIXED TRACTION INCORPORATED IN PLASTER

Bone Involved	No. of Cases	Device Employed
Femur	2	Steinmann pin — 1 Kirchner wire — 1
Tibia and fibula	15	Steinmann pin — 11 Kirchner wire — 4
Humerus	2	Anderson pin — 1 Kirchner wire — 1
Totals	19	Steinmann pin — 12 Kirchner wire — 6 Anderson pin — 1

TABLE IV

TOTAL EXPERIENCE WITH PLASTER ENCASEMENT METHOD 1927–1941

	No. of Cases
Present report	130
Previously reported	122
Total	252

TABLE V

COMPOUND FRACTURES TREATED BY OTHER METHODS

Period	No. of Cases
1927–1935	97
1935–1940	42
Total	139

In conclusion, we wish to repeat what we have said on numerous other occasions, namely, that this is essentially a method of dressing. It introduces no principle that has not been before the profession for many years. Lister showed that if initial contamination of wounds was promptly dealt with, the natural tendency was for wounds to heal. In 1915, Rutherford Morison introduced his B.I.P.P. (bismuth, iodoform, paraffin paste) which was employed in the same manner (with minor differences in technic) in which Orr later advocated the use of vaselined gauze. Gurd, in both military and civil practice, gave this method an extensive trial and still employs it with excellent results. We agree with Hey Groves that the method and its results must be seen to be believed. We ask that more surgeons open their eyes and their minds to the end that they may be converted.

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ABSTRACTS OF PAPERS

PRESENTED BEFORE THE FIRST ANNUAL ASSEMBLY
OF
THE CENTRAL SURGICAL ASSOCIATION

ANN ARBOR, MICH., FEBRUARY 28–MARCH 2, 1941

PRESIDENT'S ADDRESS

THE INAUGURATION OF THE CENTRAL SURGICAL ASSOCIATION

Roy D. McClure, M.D.
Detroit, Mich.

MEMBERS OF THE CENTRAL SURGICAL ASSOCIATION and honored guests: Your president and officers tender you this formal welcome on behalf of our hosts, Dr. Frederick A. Coller, and his staff, of the University Hospital and the Medical School of the University of Michigan.

In addressing this, the inaugural meeting of the newly founded Central Surgical Association, I wish to voice my appreciation of the honor that has been conferred upon me by being chosen its first president. My election to this office is probably a token of recognition of a rôle played in the formation of our Society, and while it is true that the concept of the organization originated with me, I wish to stress that the greater credit of its sound foundation belongs to those Fellows of the American Surgical Association who have agreed to act as its sponsors.

I have long believed that a genuine need existed for a society such as is now gathered here, and the reasons for my belief were manifold.

I have always prized very highly the inspiration and stimulus derived from my membership in the older surgical societies. The benefits of active membership are quite evident, yet the opportunities offered to a great group of surgeons for belonging to them have, to my mind, been too limited. I reached this conclusion by looking back on a number of barren years in my own life during which I missed keenly such inspirational contacts.

Some years ago I came to realize that a great many able, well-established, and excellently qualified surgeons had been barred from inclusion in the senior surgical societies mainly because of the "closed number" policy, while the oncoming generation of young men who have an increasingly better foundation training had even less chance. This lack of sufficiently wide dispersion of the opportunities for scientific work in the surgical societies also has aroused the interest of others. In his stirringly dramatic dialogue with the spirit of Samuel Gross, delivered in the course of his 1937 Presidential Address before the American Surgical Association, Evarts A. Graham made a forceful plea for an increase in the membership of that limited society—pointing out that while the population of the country had increased 160 per cent (and the number of surgeons undoubtedly more) since the inception of that body, the number of its members had

been raised only 71 per cent. Dallas B. Phemister, in his address as president of the American Surgical Association in 1939, expressed a similar idea, and, in addition, brought the problem of the younger surgeons into official focus, when he stated: "Limited membership excludes too many of the ever-increasing number of surgeons who are qualified to take part in the programs and who should profit by the proceedings. The competition is so stiff that men are not usually elected to fellowship until they are mature surgeons, unless they have accomplished outstanding investigations." He went on to say that the enormous influence of the German Society for Surgery had been due to the inclusive policy of the membership. Anyone specializing in surgery, using the German language, and recommended by two members of the society was eligible for election, subject to the approval of the executive committee. The membership at the time was close to 3,000.

In concerning myself specifically with the Great Lakes and Central section of the United States and Canada, additional factors strongly hindering the opportunities for activity in surgical societies became apparent. One was the policy of regional restrictions of the Southern, Western and New England Surgical Societies, and the other the element of geographic distance. The importance of both was obvious. And while thinking in terms of geography, I could not help reflecting on the curious circumstance that of all the important cartographic divisions of our country the potentially most important one, the Midwest, was the only one lacking its own surgical society.

These considerations made it clear that an unmistakable need existed for a surgical society with its headquarters in the Central and Great Lakes region with the primary purpose of serving the younger generation of surgeons. Gradually, a detailed concept was formulated. This society has been projected as a proving ground for young surgeons, many of whom later undoubtedly will become eligible for one of the older societies: as stimulus when this is most needed; as a bridge between the time of completion of residency, acceptance by the Boards, and the arrival at the period of recognition as surgeons—a time interval during which many young surgeons stagnate through inaction and lack of stimulation by a scientific surgical society.

As a result, I communicated the plan thus taking shape to some of my colleagues in the American Surgical Association, requesting their comments. That the reception was enthusiastic is attested by the speedy fruition of the project. I was interested to note that times and people change but little, for those who demurred offered the same objections as those advanced by the opponents of Samuel Gross and the other founders of the American Surgical Association in 1879. The claim was made then, as now, that with the country full of all sorts of surgical societies there was no need for such an organization. The suggestion has also been made that this society might encroach upon the regional meeting of the American College of Surgeons in this area. In reply to this charge I can do no better than again quote the words of Samuel Gross when he was similarly accused of striking a blow at the American Medical Association: "We can hurt no society now in existence or likely to come into existence. We can hurt only ourselves if we fail to do our duty."

AIMS OF THE SOCIETY

All medical organizations have been started with the same high ideals; namely, to promote the art and science of medicine, to encourage the acquisition of knowledge by their members and to aid in the improve-

ment of the general health of the community. Too often these ideals have been lost sight of because attention has been focused on what seems to be more pressing problems involving the welfare of the members. It is my belief that such matters as medical ethics, medical economics or medical politics have no place in a purely scientific organization. Let us then resolve to abstain from the discussion of all such irrelevant questions and direct our energies toward developing better surgeons and thereby to improve the practice and knowledge of surgery. If this goal can be achieved, problems of ethics and policy will solve themselves. At this point, I desire to sound a note of warning to the Membership Committee: that while certain minimum training requirements are essential for membership, they should not be interpreted so rigidly as to make the organization appear to exist for the exclusion rather than the inclusion of promising members.

It has long been apparent that there should be some restrictions or rules governing the practice of surgery. All improvements in the regulations concerning the practice of medicine have been suggested very appropriately by the physicians themselves. From apprenticeship under a practicing physician, or one year in medical school, the medical course has extended to two years, three years and, finally, four years with the suggestion lately that it be lengthened to six years.

State laws requiring minimum academic standards for the practitioners of medicine are of comparatively recent origin. Strangely enough, surgery, that branch of practice in which the greatest good can be accomplished by the skilled, and the most harm by the unskilled, has not been affected by any legislative requirements. Again, the pressure for the improvement of surgery is fortunately coming from within the ranks of the profession itself. As you may know, the American Board of Surgery was sponsored by the American Surgical Association, the American Medical Association, the New England Surgical Society, the Southern Surgical Association, the American College of Surgeons, the Western Surgical Association and the Pacific Coast Surgical Association.

The American Board of Surgery is now functioning smoothly, and I am convinced that it is already exerting a most beneficial influence. This is evidenced by the ambition of all the men in training in our hospitals to prepare themselves for the various surgical specialties, as well as by the greatly increased numbers of men applying for advanced training in order to prepare themselves for acceptance by the various Boards.

The desire for adequate training is evident but the facilities for such preparation have been regrettably inadequate. There is a real need for more surgical residencies if we hope to turn out enough trained men to provide for the surgical needs of the country. As a result of this deficiency many have been starting the practice of surgery after one or two years internship. It is true that in the past many men with scant opportunity for training, except in the expensive school of personal experience, have become great surgeons, but it is obvious that the longer supervised training is much more desirable. One of the obligations of members of our association should be to rectify this condition. The University hospitals alone cannot fill the need. The large general hospitals must reorganize their staffs and services so that longer residencies can be provided. Adequate intern and resident instruction and supervision, together with laboratory facilities for experimental work, are essential. Arrangements must also be made for cooperation with State Universities or the nearest medical schools, in order to provide opportunities for taking advanced surgical degrees. This plan has worked successfully for years between the Surgical

Department of the Henry Ford Hospital and the University of Michigan Medical School. The preparation of a thesis has served as a definite stimulus to our residents, while the recognition of the teaching of our senior staff surgeons by the University has been of inestimable inspiration to us. I urge you to inaugurate, if possible, a similar scheme of training in your institutions if you now have no University connections. This is one certain method of making a definite contribution to surgical progress.

You are in the fortunate position of having your society launched and sponsored by members of a senior surgical group, the American Surgical Association. This must be a start, unique in the annals of medical societies, for only too often in the past new societies were formed by dissenting members of old ones. Here there is no dissension, but rather an example of benevolent paternalism in which the fledgling organization will have the benefit of wise and seasoned counsel before swinging out on its own course. Those in the Founders' Group, by virtue of their age and membership in the senior society, now become senior members of the Central Surgical Association, as set forth by your constitution. Their chief function will be to act in a purely advisory capacity, to counsel and guide when needed, in order that your society shall be a mighty force, not only in shaping more skillful, conscientious and progressive surgeons, but in stimulating investigative work for the advancement of the science of surgery.

It is the fervent wish of your officers that in the faithful performance of this program the Central Surgical Association may have a just success and an illustrious future.

Symposium on Gastrointestinal Surgery

GASTRIC RESECTION FOR ULCER

Experience in Forty-four Cases

C. Fremont Vale, M.D.
Detroit, Mich.

OUR MEDICAL COLLEAGUES can treat successfuly over 85 per cent of duodenal ulcers. Those which require surgery have developed a more or less extensive duodenitis with fibrosis of the wall, particularly the muscularis, which forms a poor base for restoration of normal mucosa. These pathologic changes are irreversible. In all of this series, the duodenum has been densely adherent to the pancreas. Ten had had previous perforations, two having had two each; yet at operation a posterior ulcer was present in all.

If the internist can continuously control pylorospasm, hypermotility, hypersecretion, and hyperacidity the patient will remain well. The surgeon should attempt no less. Pyloroplasty and gastrojejunostomy fulfill these requirements indirectly and incompletely. High resection controls these factors completely and directly. It is, therefore, advocated.

The six deaths have been attributed to errors in technic and judgment. Correction of these have allowed the last 39 resections, for all conditions, to be undertaken, with two deaths—one of which occurred in a man, age 80, with cancer; the other being the last of the above errors. These six deaths with correction of error are as follows: First, breaking down of anastomotic suture line. Only two rows of sutures were then being used. Since that time a third row has been added, with the

von Petz clamp placing clips as the first. The next two, opening of the duodenal stump. Because of dense adhesions to the pancreas, timid dissection did not allow sufficient cuff for inversion and secure closure. Now a finger is placed inside the duodenum as a guide to dissection and a good closure secured. Two other deaths were due to pulmonary complications following intratracheal anesthesia. This method was used eight times in this series, with seven major lung complications. It has been discontinued and no further pulmonary deaths have occurred. The final case had a fistula between an apparently normal gallbladder and the duodenum. The opening in the gallbladder was closed. It opened, a subdiaphragmatic abscess formed and was drained, but death occurred two months later due to liver abscess. Had the gallbladder been removed or drained this patient would still be alive.

In this series are seven resections for exclusion, with one death. The remaining six are clinically well, though the antral mucosa was not removed. There is no free acid in the gastric contents of the three studied later. We believe the antral mucosa should be removed, but that added experience will mean fewer exclusions.

The operation has been completed with antecolic anastomosis without entero-enterostomy 17 times. The first one was performed six years ago. All have had good functional results. Roentgenologic studies in several have shown no stasis in the proximal loop. It is simpler, easier, and more quickly accomplished. The difficulty of attaching the transverse mesocolon to the stump of the stomach after high resection is eliminated, together with the possibility of proximal loop obstruction. Subsequent operation, if necessary, is much more simple. Retrocolic anastomosis may be preferable following resection for jejunal ulcer where the transverse mesocolon is already opened, or where the mesocolon is unusually long.

Restoration by the Billroth I method is not used because of the duodenal pathology described, as well as the temptation to do a less high resection.

DISCUSSION.—DR. HENRY K. RANSOM (Ann Arbor, Mich.): I should like to ask Doctor Vale about the mortality of gastric resection. He mentioned 13.6 per cent. I wonder if that is a composite or the present mortality, and if there has been a lower mortality with greater experience.

DR. C. F. VALE (Detroit, closing): I should not like to have this group go away with the idea that I am operating upon stomachs at the present time with a mortality of 13.6 per cent. We have profited by the mistakes that we have made. I spoke of that as a tragedy of errors. None of those errors have been repeated. At the present time, in the last 39 resections for all conditions, including ulcer and cancer, there have been but two deaths. One of those occurred in a man, age 80, with carcinoma of the stomach, who slipped out about three weeks later, and the other, is one that has been described.

So, on the basis of our present experience, we feel that had we those cases to do over again, in the present series of 44 cases, we would have no mortality. That sounds too good to be true, but those same mistakes have not recurred. I believe that at present we can offer a patient a mortality rate, in case of ulcer, of somewhere between 1 and 3 per cent.

REGIONAL LYMPHATIC METASTASES OF CARCINOMA OF THE STOMACH

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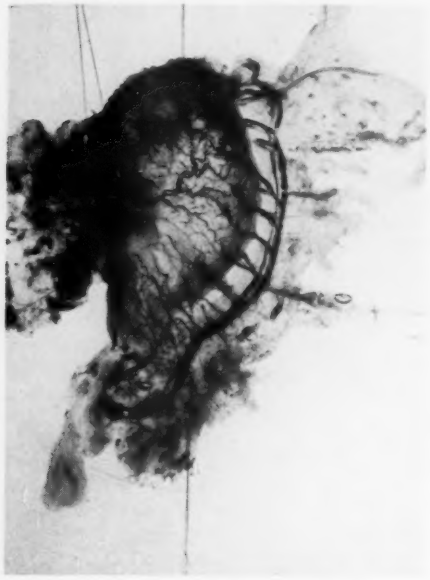
From the Department of Surgery, University of Michigan, Ann Arbor, Mich.

A KNOWLEDGE of the incidence and location of lymphatic metastases from carcinoma primary in the stomach is essential in the treatment of this disease. This study, similar to one made by us on the regional lymphatic metastases of carcinoma of the rectum and colon, is based upon the thorough dissection and examination of all the lymph nodes from 53 cases of carcinoma of the stomach. Of these, 51 followed partial to subtotal gastric resections, and two were autopsy cases. The lymph nodes were dissected from each specimen after they had been visualized (Fig. 1 A) by clearing by

the Spatteholtz method as modified by Gilchrist and David. All nodes were examined individually and the results charted upon diagrammatic drawings, upon which each node was indicated (Fig. 1 B). The presence or absence of lymph node metastases was then correlated with (1) the age of the patient; (2) duration of symptoms; (3) location of the neoplasm within the stomach; (4) size; (5) gross type of neoplasm; (6) depth of infiltration; (7) degree of cellular differentiation; and (8) microscopic type.

As a result of this special method of in-



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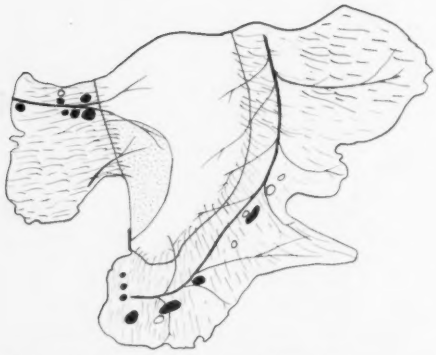
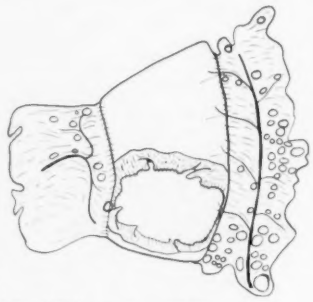


C.Z. 434779 43 M DURATION 4 MO.

GROSS: 6 CM. ULCERATED LESION UPON LESSER CURV.
MICRO: SCIRRHOUS CARCINOMA Gm INFILTRATING THRU GASTRIC WALL. ULCERATING SURFACE.
LY N: 19 LY. N. ISOLATED. 13 SHOWED EARLY SUBCAPSULAR NESTS OF ADENO-CARCINOMA.

B

FIG. 1.—Case No. 434779: (A) Photograph of cleared specimen following partial gastric resection for carcinoma of the stomach. (B) Line drawing illustrating the numerous small lymphatic metastases, even though clinically no metastases were thought to exist.



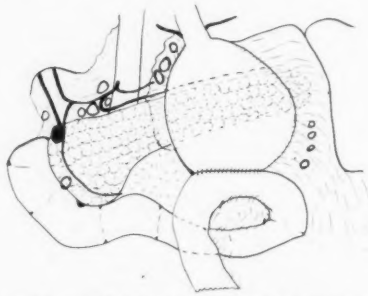
L.G. 437675 M 55 DURATION 2 YRS.

GROSS PARTIAL GASTRECTOMY. LARGE POLYPOID MASS & ULCERATING CENTER BEGINNING AT PYLORUS AND EXTENDING UPWARD FOR 6 CM. COMPLETELY ENCIRCLES PYLORUS. INFILTRATES POSTERIORLY INTO PANCREAS. PYLORUS PATULOUS.

MICRO FAR ADVANCED PAPILLIFEROUS ADENOCARCINOMA Gm. INFILTRATING INTO SUBMUCOSA OF DUODENUM AND INTO FIBROUS TISSUE SURROUNDING PANCREAS.

A

AUTOPSY SPECIMEN OF L. G. 437675 A29IAQ. ANTERIOR VIEW OF REGIONAL ANATOMY FOLLOWING PARTIAL GASTRIC RESECTION.



MICRO NO EVIDENCE OF REMAINING CARCINOMA IN DUODENUM NOR PANCREAS FOUND. NO HEMATOGENOUS METASTASES.

LY N. 89 LY. N. ISOLATED. 1 LY. N. ALONG COURSE OF GASTRODUODENAL ARTERY SHOWS A LARGE NEST OF METASTATIC CARCINOMA.

B

FIG. 2.—Case No. 437675: (A) Line drawing of the operative specimen from a carcinoma of the stomach, demonstrating the absence of nodal metastases even though as many as 60 lymph nodes were isolated. (B) Line drawing of the residual lymphatic metastases found at necropsy. It will be noted that even though all of the susceptible node-bearing area was thought to have been removed at the time of operation, further examination revealed a singular metastasis in a lymph node adjacent to the duodenal stump (Zone I).

vestigation, 75.5 per cent showed regional lymph node metastases. Many of the cases in which no metastases were found were from operations which were purely palliative in character, because of either extensive local infiltration or poor operative risk (age), and only small segments of the adjacent mesenteries with their included lymph nodes were resected. It is safe to assume that if more of the adjacent supportive tissues could have been resected, and examined for lymph nodes, the percentage of cases having lymph node metastases would more closely approximate 88 per cent in this series.

The four zones of lymphatic metastases from carcinoma of the stomach are discussed. Special emphasis is placed upon complete resections of Zone I (the subpyloric inferior gastric zone) and Zone III (the superior gastric zone)—the two zones in which residual carcinoma is invariably found, as demonstrated by careful examinations of the lymph nodes in necropsy specimens from postoperative deaths, even though clinically there were no residual nodes palpable, and all of the carcinoma was thought to have been removed (Fig. 2).

No relation was found between the duration of symptoms and the presence of metastases. There were five cases with duration of symptoms for over one year, who were found to be free from regional lymph node metastases. Several of these cases were of two and three years' duration. In contrast to this, there were six cases whose symptoms had ranged from one to three months that were subsequently found to have metastasized.

Furthermore, there was no relation between the size of the neoplasm and the presence of metastases. Several of the largest neoplasms had not metastasized, and many of the small neoplasms had. The largest neoplasm was 14 cm. in length. This showed no evidence of metastases. The smallest neoplasm was 2 cm. in length and this had metastasized.

One of the most significant correlations was the high incidence of lymphatic metastases from the sessile neoplasms as compared with the polypoid. All of the carcinomata were examined grossly as soon as they were removed to determine their gross characteristics. The sessile neoplasms had an incidence of metastases of 95.4 per cent in comparison to 60 per cent for the polypoid neoplasms. This demonstrates the necessity for very wide resection of the adjacent lymph node-bearing tissues, if the surgeon hopes for a cure.

Hope is expressed that operative procedures will be so designed as to adequately include all of the zones of lymphatic metastases regardless of the duration of symptoms, the size of the neoplasms, the presence or not of palpable nodes, and the clinical presence or not of metastases, so that the eventual number of five-year cures for carcinoma of the stomach might be increased.

REGIONAL ENTERITIS

Report of Cases

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INCIDENCE.—The increase in the incidence of regional enteritis is greater than can be accounted for by improved diagnostic methods and greater alertness on the part of the profession in general. In a series of 26 patients with regional enteritis, studied at the Henry Ford Hospital, 80 per cent were under age 40, and one-half of them were between the ages of 19 and 39. The male-female ratio was 4:3. None of the patients were Hebrews.

Symptomatology.—The symptomatology corresponded to the phase of the disease encountered. In 25 per cent of the patients, the symptoms simulated acute appendicitis, indicating the acute stage of the disease. Evidence of the subacute or ulcerative stage, such as diarrhea and hemorrhage, was present in an equal number of patients. The late stage of the disease was manifested by obstructive symptoms in 40 per cent of the patients, and fistula formation in the remaining 10 per cent.

Diagnosis.—A correct preoperative diag-

nosis was made in only one-third of the patients, and in the majority of these the disease was in the third stage, so that positive roentgenographic findings were present. All but one of the acute cases received emergency operations, with the diagnosis of acute appendicitis. In the other patient, acute obstruction was found. In three of the patients presenting signs of chronic intestinal obstruction, the preoperative diagnosis in two was chronic intestinal obstruction, cause unknown, and in the other carcinoma of the small intestine. Three patients were operated upon for intestinal fistula following celiotomy, but in none was regional enteritis suspected until the abdomen was opened. In one patient, the diagnosis was completely missed because massive intestinal hemorrhage was the chief symptom. Increasing experience with the disease will decrease the number of diagnostic errors in all but the acute stage of the disease, for it is probable that the diagnosis in the acute stage will continue to be made at celiotomy for suspected acute appendicitis.

Treatment.—If the disease is encountered in the acute stage, the abdomen should be closed without removing the appendix because of the danger of fistula formation, though no complication followed the removal of the appendix in seven of our own acute cases. Resection is the operation of choice in uncomplicated subacute and chronic stages. It is important to defer operation in the subacute stage until exacerbations have completely subsided. Failure to realize the profound toxemia accompanying a flare-up of the disease was responsible for death from circulatory collapse in one of our patients. Short-circuiting operations should be reserved for complicated cases of fistula in which subsequent resection is planned. Resection should be as radical as though malignancy were present, if recurrence is to be avoided. In this series, resection was performed on 17 occasions without a death. There were two deaths in our series following entero-anastomoses, both due to circulatory collapse. The total mortality for the series was 6.7 per cent (two deaths in 30 operations).

Location of the Lesion.—The terminal ileum was implicated in 90 per cent of the patients, and in 78.4 per cent it, alone, was the site of the lesion. In two cases, the cecum was invaded and in three patients, the disease spread to the jejunum. The lesions were confined to the jejunum in only one instance.

Follow-Up.—Of the seven patients upon whom appendicectomy was performed during the acute stage, five are well, one returned for resection, and one was reoperated upon for obstruction due to adhesions. One-third of the patients upon whom resection was performed suffered from recurrence and required further operation. One patient upon whom operation was not feasible, because of the extensive nature of the disease, has remained in fair health under a rigid medical regimen.

SURGERY IN ULCERATIVE COLITIS

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As the result of investigations recently reported by Cave,[1] Stone,[2] Lahey,[3] and others, certain precepts have been established in the surgical treatment of ulcerative colitis. Appendicectomy, cecostomy, and, except in certain few cases, colostomy have been discarded as ineffective surgical measures in the treatment of ulcerative colitis. Ileostomy is the treatment of choice both as a complete method in itself or as a preliminary to resection of the colon. Surgery should be undertaken in: (1) Acute fulminating type of colitis, in which it is the only hope for the patient; (2) in progressive chronic colitis, with beginning irreversible changes in the bowel wall; and (3) in very chronic cases with stricture, polyposis or pseudopolyposis or multiple fistulae. Severe hemorrhage or impending perforation are not, in themselves, indications for ileostomy. The preoperative preparation has been ably described by Cave and Nickel.[1] The anesthesia used was either cyclopropane inhalation, or local procaine infiltration. The double-barrel or loop-ileostomy was the procedure employed until the past year. More recently, the method preferred is the divided ileum, with either a transplanted distal loop, or with the distal end closed and returned to the abdominal cavity. This enables one to have a protruding ileum, two to four inches in length, to fit into a bag and helps to prevent irritation and digestion of the surrounding skin.

as suggested by Cattell.[4] A survey was made of all cases of ulcerative colitis admitted to the Wisconsin General Hospital since 1926. There were 125 cases seen on the Medical and Surgical Services. Of these, 98 were treated medically. A follow-up was possible in only 46 cases. Of these, 15, or 32.5 per cent, were dead. There were 27 cases treated surgically, with ten deaths, a mortality of 37 per cent. These can be analyzed as follows: Seventeen had ileostomies, with four deaths, a mortality of 23.5 per cent. There were six cecostomies, with two deaths, or 33 per cent mortality. Colostomy was established in two cases. Both died of perforation and peritonitis. Ileosigmoidostomy was performed in four cases. Nine cases had a partial or complete colectomy following ileostomy, and two, following ileosigmoidostomy. There were two deaths, a mortality of 18 per cent. One case with a far-advanced ulcerative colitis, of nine years' duration, complicated by carcinomatous degeneration of the polypi and a generalized carcinomatosis, died four days after an exploratory celiotomy.

Discussion.—It is evident from a review of these cases that appendicostomy, cecostomy, and colostomy were of little value in the treatment of this disease. Ileostomy performed early, may allow later establishment of the continuity of the bowel, but in none of our cases was this directly accomplished. The high mortality of ileostomy is due primarily to the delay in coming to surgery. This results in an advanced stage of intoxication, infection, and imbalance of the body electrolytes. Earlier ileostomy should lower this mortality. Progress following ileostomy was checked by frequent clinical and roentgenologic examinations. In this series, only late cases with irreversible changes in the bowel were submitted to surgery. This was due to the failure of the Medical Service to seek surgical consultation until all medical measures had failed. Resection of the rectum following colectomy was indicated only where there was polyposis or evidence of persistent inflammation.

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DIVERTICULITIS OF THE COLON

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THE word diverticulum means literally a by-path. It is a blind-tube, or sac, branching off from a principal channel. As ordinarily employed, the term includes two types: (1) Those which are congenital, and contain all the layers of the wall of the organ involved; and (2) those which are acquired, and which contain only a part of the wall permitting the protrusion. We are here interested in diverticula of the colon which are usually acquired.

Since the incidence of this defect occurs in 5–10 per cent of the population over age 40, it must be kept in mind as a possible diagnosis whenever bowel dysfunction is encountered.

Etiologic Factors.—The causes of diverticulosis are not definitely known, but a combination of factors is probably responsible. Since most diverticula are acquired, they probably arise from an increase in intraluminal pressure and a decrease in the resistance of the bowel wall to that pressure. The former may be caused by: (1) The smallness of the bowel lumen at the junction of the rectum and sigmoid; (2) spasm of circular muscle. The latter, that is, the decreased resistance of the bowel wall, may be influenced by (a) large canals for the entrance and exit of vessels; (b) congenital defects; and (c) wear and tear of muscles as age increases.

Pathology.—Diverticula are usually covered by mucosa and submucous only. However, there may be subserous fat and serosa, or variations of these layers, but almost never circular muscle. They may be large or so small as to be almost microscopic, and, thereby, evade roentgenslogic detection or gross inspection, and yet give rise to symptoms and signs.

Diverticula may be the seat of simple

inflammation, which may be severe enough to interfere with blood supply, causing gangrene with perforation. This, in turn, may give rise to: (1) Local abscess; (2) general peritonitis; or (3) fistula. In addition, the diverticula may become chronically inflamed, causing a thickening of the entire bowel wall and obstruction.

Symptoms and Signs.—Uncomplicated diverticulosis causes few, if any, symptoms or signs, and its diagnosis depends entirely upon the barium or double-contrast enemata. The complications present signs readily interpreted in most cases; however, almost any lesion of the large bowel may be mimicked.

Prognosis.—The prognosis in diverticulitis, regardless of the mode of treatment, is not good. In the 203 cases of our series, 37 were treated surgically; there were five deaths, a mortality rate of 13.7 per cent. In 166 cases, no surgery was undertaken, and the mortality rate was 1.2 per cent (two deaths). The total mortality was seven deaths, or 3.4 per cent.

Treatment.—Uncomplicated diverticulosis requires no treatment. David, and others have called attention to the use of low residue diets and mineral oil to prevent complications. We are using solid petrolatum, which has a high melting point and desirable lubricating action, without producing a mushy stool. Acute diverticulitis requires a low residue diet, bed rest, sulfonamides, petrolatum, attention to water balance, and blood transfusion, if necessary.

Sudden perforation is an emergency requiring the turning in of the peforated diverticulum and its covering with omentum, if feasible. If not, the loop of bowel should be mobilized and placed outside the abdomen and a tube anchored. Local abscess should be adequately drained, and spreading peritonitis is treated in the classic manner. Fistulae are best treated by dividing the fistulous tract and turning in both sides, then interposing omentum. In addition, some form of diversion of fecal current may be temporarily necessary.

Chronic diverticulitis, without obstruction, may be best treated by resection, if only a small part of the bowel is involved. This is not always feasible because of the difficulties encountered in mobilization.

Chronic diverticulitis with obstruction demands, first, a diversion of the fecal current and then resection, if possible. If not possible, because of the extensiveness of the lesion, then the involved portion of the bowel should be brought out onto the abdomen through a muscle-splitting incision and held there until it returns to normal. This will occur in most instances within a relatively short time; then the loop may be allowed to drop back beneath the transversalis fascia. This operation, which was performed in two cases, was followed by good results. It was first described in a slightly different manner by Houston.

SUMMARY

The commonness of diverticulosis, and the prevalence of complications in the diverticula, require that this disease be kept in mind when any symptoms are referable to the large bowel. The treatment depends upon the complications. In chronic cases, resection is most desirable; however, some form of diversion of the fecal current is perhaps most commonly employed. The procedure of extrusion of the inflamed loop for a period of time, allowing it to return to normal and then permitting it to drop beneath the fascia, is recommended in those cases where resection is not feasible.

BILE PERITONITIS

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BILE PERITONITIS is that condition in which there exists a variable amount of free bile within the peritoneal cavity, with resultant peritoneal reaction. Eight clinical cases of this condition have been observed in private practice and on the Surgical Service at the University of Nebraska Medical School since 1935. Seven of these cases occurred in women, the average age of the group being 60 years. In only one was the condition present on admission, the complication developing during the postoperative period in the remaining seven. Each of these seven patients was operated upon for recurrent calculous cholecystitis, a cholecystectomy being performed in each instance, with an associated choledochostomy in one case. The one patient admitted with bile peritonitis, without previous surgery, was moribund when brought

to the hospital. An admitting room diagnosis of coronary thrombosis was made, and the true pathologic picture was disclosed by autopsy. In only two instances was the onset of the biliary peritonitis following surgery later than the fifth postoperative day.

The fulminating character of the complication was emphasized in the five fatal cases, one of whom succumbed 18 hours after the onset; three died within 48 hours, and only one of the group lived until the fourth day. The presenting symptoms in this group of patients were distention, abdominal pain, tenderness, tachycardia, and shock. The features of distention and shock were striking in nearly every instance. Profuse drainage of bile along the abdominal drain was noted in four cases and was of assistance in arriving at a diagnosis.

Autopsy was permitted in four of the five fatal cases, disclosing in each instance a diffuse bile peritonitis with free bile ranging in amounts from 200 cc. to two liters. Perforation of the stump of the cystic duct was demonstrable in two instances, and probably accounted for the death of that patient on whom no autopsy was permitted. No actual site of perforation was found in two cases. Stones were found in the common duct in three of the four cases examined, and it is suggested that this factor accounts for the majority of those instances in which subsequent perforation of the extrahepatic tree occurs.

Two of the three cases which recovered required secondary drainage. The third patient recovered after a period of two weeks, during which time there was profuse drainage of bile along the drain in the gallbladder fossa.

Etiology.—A review of the subject of biliary peritonitis discloses a variety of ways in which this condition may be produced:

(1) Biliary peritonitis without gross evidence of perforation, either idiopathic or the site being microscopic in size.
(2) Biliary peritonitis following surgical trauma—due to accessory bile ducts in the gallbladder bed, absorption or slipping of cystic duct ligature, or increased intrabiliary pressure following cholecystectomy from overlooked common duct stone.
(3) Biliary peritonitis from infection.

Our observations lead us to believe that increased pressure within the biliary tree from overlooked common duct stones is the most frequent basic factor in the production of biliary peritonitis. Accessory hepatic ducts entering the gallbladder directly from the liver bed are probably next in importance as a source of diffuse biliary leakage. If the patient survives, infection almost always appears as an accompanying feature.

Pathology.—Free bile in the peritoneal cavity produces its serious effects through one or a combination of several of the following ways:

(1) Toxic action of one or more of the products present in bile upon tissues.
(2) Infection. This may be carried into the peritoneal cavity by the bile or subsequently develop through contamination.
(3) Production of a condition simulating surgical shock through the outpouring of large amounts of plasma-like fluid into the abdomen from the blood stream, associated hemoconcentration, lowered blood volume, and fall in blood pressure.

Clinical and experimental observations suggest that this syndrome simulating surgical shock, which frequently accompanies biliary peritonitis, is sufficient to cause death in many instances, and if not lethal, it so lowers normal resistance that the subject is unable to resist bacterial and toxic factors which normally would not prove fatal.

Clinical Picture.—Biliary peritonitis should be suspected in any patient who has recently been subjected to surgery of the biliary tract and subsequently presents a picture simulating surgical shock. One's suspicions are naturally confirmed if bile is found escaping along the abdominal drain in considerable amounts. Bile peritonitis developing without previous biliary surgery is rarely diagnosed before a diagnostic celiotomy is undertaken.

Treatment.—The successful treatment of bile peritonitis demands adequate drainage as soon as the condition is recognized. Ideally, one should be able to close the site of perforation, in addition to instituting drainage, but this is rarely possible. Fluid loss should be replaced by parenteral routes and the administration of whole blood or blood plasma is especially valuable.

Mortality.—Diffuse biliary peritonitis is an extremely serious complication following biliary surgery and results in a very high mortality. The mortality in this group of patients was 62 per cent. Improvement in these results demands that one suspect this complication when certain of its symptoms

and signs are present and institute immediate drainage.

DISCUSSION.—DR. J. DEWEY BISGARD (Omaha, Nebr.): I should like to ask Doctor McLaughlin if there is any difference in the incidence and mortality of bile peritonitis in the cases drained as compared with those undrained.

DR. CHARLES W. MCLAUGHLIN, JR. (Omaha, Nebr., closing): In this series, all of these cases, with one exception, were drained. The practice in Omaha, at the present time, is to institute drainage in practically all cases following cholecystectomy. A recent case was admitted to the hospital with bile peritonitis, a cholecystectomy having been performed elsewhere, without drainage. Since six of our eight cases developed in drained cases, it is obvious that a drain does not prevent the development of bile peritonitis, but we feel safer when we routinely provide an outlet for free bile.

THE FORGOTTEN MOYNIHAN TUBE

In Acute Mechanical Obstruction of the Small Intestine

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ACUTE MECHANICAL BLOCK of the small intestine is still one of the gravest and most disastrous emergencies to confront the surgeon. We cannot help it if a case is brought to us late, but we can be held accountable for any delays, once the responsibility is ours.

There is always an accumulation of fluid above the point of block. It is held there, except for what may be lost in the vomitus, because, first, it cannot pass the point of obstruction; and, second, reabsorption which normally takes place ceases. We have, then, the problem of loss of fluids and salts, a bowel loaded with fluid that soon becomes highly toxic, with threatened toxemia. Fluids and salts can be replaced very readily, the stomach can be lavaged and suction drainage instituted. If it is the accumulated toxic material in the bowel that kills, the answer will be dictated by common sense, namely, that the accumulation must be given egress as soon as possible and, of course, the cause of obstruction must be removed.

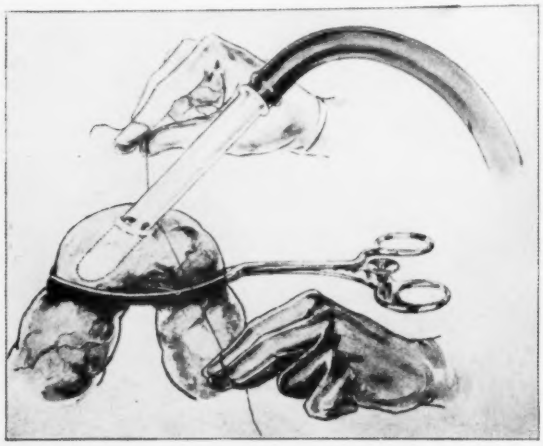

FIG. 1.—Clamp applied to prevent escape of fluid when incision is made for the drainage tube. The purse-string suture then serves the same purpose.

The Moynihan tube, now pretty much forgotten, affords a means of emptying the accumulated, toxic fluid expeditiously, by a simple surgical procedure that can be accomplished in about 15 minutes, without soilage or discomfort to the patient. Decompression results in improvement of the circulation of the intestinal wall right under one's eyes; the emptied bowel is then easily handled. Decompression should precede releasing the obstruction, thus preventing the pent-up toxic fluid to pass down into "thirsty" collapsed bowel for rapid absorption.

The Miller-Abbott tube is advocated to-day for all types of obstruction, including acute mechanical block. Where time is so important a factor its use may be disappointing and costly. It cannot always be passed beyond the duodenum, or its passage may be slow, too slow! Its application is disturbing to a sick patient, likewise the fluoroscope for its guidance.

The Moynihan tube also has limitations, but in acute mechanical block no other method yet devised meets the requirements in as expeditious a fashion. It is, moreover, simple and safe as well as effective.

Technic.—A knuckle of intestine, in

about the midportion of the obstructed bowel, is stripped free of its contents, if possible, and a rubber-covered clamp applied to prevent the escape of fluid from the incision made to admit the drainage tube. If the intraluminal tension does not permit of stripping it free, collapse is effected by using an hypodermic needle. A purse-string suture is then introduced into the wall opposite the mesentery before opening the intestine. An incision is made in the center of it, just large enough to admit the tube. As soon as the tube has been introduced beyond the tip, the purse-string is pulled taut (Fig. 1), to prevent soilage, and the clamp removed. The tube is passed up into the intestine as far as the flange in one direction. It is then withdrawn far enough to permit it to be swung over so that it can be pushed down into the intestine in the opposite direction. If there is still unloaded intestine that cannot be pushed onto the tube, it can be held up and its contents allowed to run out by gravity.

Moynihan's technic does not include the use of the covered forceps, hypodermic needle, and purse-string suture. This refinement makes it possible to accomplish drainage without soilage, thus preventing a superimposed peritonitis.

My experience with this tried and tested Moynihan tube (refined technic) impels me to recall it to your attention, and to advocate a revival of its use in acute mechanical obstruction of the small intestine.

DIFFERENTIAL DIAGNOSIS AND SURGICAL CARE OF JAUNDICED PATIENTS

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DIFFERENTIATION between medical, or hepatogenous jaundice, and the surgical, or obstructive forms, is often very difficult. This is especially true when the patient is not seen until jaundice has existed for many weeks or months. A careful evaluation of the clinical history is of greatest importance. Unfortunately, atypical symptoms are too frequent to permit any group of criteria to establish a diagnosis. Laboratory studies are often valuable. Liver function tests may give diagnostic information in the early stages of jaundice. In the hepatogenous form, primary damage of the liver cell exists, and may be demonstrated by the more delicate functional determinations, whereas in the obstructive types of jaundice, liver damage usually is delayed. As the duration of jaundice increases, cell damage exists in all types, and functional tests are of value, chiefly, in determining the ability of the patient to withstand surgical intervention.

The most frequent evidences of toxic or infectious intrahepatic jaundice are a history of the ingestion of a liver toxin or the preexistence of some infectious disease. Icterus gradually increases without associated pain or pruritus. Bile is present in the intestinal tract at all times but may be diminished in amount. The liver may become enlarged and tender but later the tenderness usually disappears, and the spleen often becomes palpable. If the disease progresses, liver insufficiency, ascites, weakness, and emaciation ensue.

Obstructive jaundice results most frequently from calculi within the choledochus; malignant tumors encroaching upon its lumen; or strictures of the duct. Symptoms of these lesions vary in accordance with the completeness and constancy of the obstruction, and the presence or absence of infection.

Calculi usually produce an intermittent jaundice, with associated colicky pain due to a ball-valve action of the stones. Longstanding "biliary dyspepsia" precedes the onset of jaundice. Bile usually is present in the intestine but varies in amount inversely with the degree of icterus. Fever may or may not be present depending upon the existence of infection. Occasionally, stones become impacted in the common duct, producing constant jaundice, often with absence of pain. Impaired liver function is not manifested until late in the disease.

A majority of malignant lesions producing obstructive jaundice cause symptoms which make the diagnosis apparent. The onset of jaundice is painless and progresses to its maximum by a gradual, steady increase. Pruritus almost invariably is present. Infection is uncommon. The gallbladder frequently is palpable below the

liver edge. When the obstruction becomes complete, bile will not be found in the intestine. In the early stages, liver function tests show little alteration except for an increase of regurgitation products in the blood.

Strictures of the choledochus, almost invariably, result from complications of previous biliary surgery. Because infection of the bile ducts usually accompanies this condition, chills and fever are common. As the obstruction rarely is complete, bile will be present in the intestine or an external biliary fistula will exist. Jaundice may vary in degree but rarely disappears. Liver damage progresses rapidly because of the existing infection.

Patients demonstrating each of the above-mentioned types of jaundice and who presented difficult diagnostic problems were discussed.

Discussion.—Differentiation between the so-called medical and surgical forms of jaundice may be a difficult diagnostic problem. This is especially true when jaundice is of long standing. As patients with hepatogenous jaundice may be greatly harmed by surgical exploration, every available aid must be utilized to establish a correct diagnosis. Fortunately, jaundice is never a surgical emergency. Patients with an early, increasing jaundice react poorly to operative intervention. Adequate time may be taken, therefore, to study such patients exhaustively. A careful history of the disease; a thorough physical examination; frequent use of laboratory tests; and daily evaluation of symptoms are necessary to determine the best form of therapy. Liver function tests are of greater value in determining the reserve capacity of the liver and its ability to withstand surgery than they are in establishing a diagnosis. Delay in instituting surgical intervention also permits adequate preoperative preparation and a restoration of as much reserve function of the liver as is possible. Jaundiced patients should always be considered to have extensive liver damage and should be treated accordingly, both before and after operation.

A CLINICAL STUDY OF CARCINOMA OF THE GALLBLADDER

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A STUDY of 45 pathologically proven cases of carcinoma of the gallbladder was made at the University of Michigan Hospital, and the results compared with similar studies reported in the literature.

Females outnumbered males 3:1, and the average age was 57.7 years. In 5,623 consecutive autopsies, primary carcinoma of the gallbladder was present in 0.39 per cent, and in 1.6 per cent of carcinoma autopsies. In 1,353 cholecystectomies, 2.5 per cent of the gallbladders revealed carcinoma. In general, these statistics compare closely with those reported by Miller, Illingworth, Smithies, Cooper, Warren and Balch, Hochberg and Kogut, and Marshall and Morgan.

The presence of gallstones plays an exceedingly important rôle in the production of carcinoma, and in 83 per cent of this series gallstones were found. Experimentally, however, proof of the production of carcinoma by gallstones is still lacking.

No combination of symptoms or signs was present in this series which would allow more than a questionable diagnosis of carcinoma. Vague upper abdominal pain was the chief complaint in 53 per cent, and was present in 86 per cent. Typical biliary dyspepsia was present in 68 per cent. Jaundice was a late symptom, and was present in 48 per cent; among those evidencing jaundice, none survived more than four months following examination or treatment here, and two-thirds of those did not survive one month.

In 23 cases studied roentgenolgically, all showed nonvisualization. Anemia and leukocytosis was not the rule.

Distant metastases were not common, but metastases were found in bone marrow, kidney, thyroid, bronchial nodes, adrenals, pancreas, and lungs.

Of 34 cases who had some type of surgical procedure, adequate follow-up has been obtained in 30. Three cases, all of which showed small lesions, have survived more than nine years, and in each case cholecystectomy had been performed. Other types of surgical procedure, such as partial

cholecystectomy, gastrojejunostomy, and choledochostomy, have shown uniformly poor results.

Carcinoma of the gallbladder remains a severe disease. Until early diagnosis can be accomplished, the prognosis will remain exceedingly poor. Not a single important contribution has been made toward the solution of this difficult problem since the first case was reported by Stoll 165 years ago.

A MODIFICATION OF "T"-TUBE DRAIN WHICH WILL PERMIT PASSING A CATHETER INTO THE COMMON BILE DUCT

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OBSTRUCTION of the common bile duct by stone which is left inadvertently or purposely, because removal is inadvisable or unavoidable, often constitutes a serious surgical problem. If "T"-tube drainage of the common bile duct has been used, the problem is simplified. The location of the concretions can be discovered by choledochography.

Cholesterol stones may be dissolved by the use of ether, or the stones may be made to pass by the use of drugs which relax the sphincter of Oddi, if the common duct is irrigated with normal saline solution.

The problem would, I think, be simplified by passing a catheter through the drainage tube directly into the common bile duct. This procedure is impossible with the usual right angle "T"-tube.

V. Mueller and Company, at my suggestion, have made a modification of the "T"-tube. The outer drainage part of the tube is attached at a 45° angle instead of the usual 90° angle. By this change, it is possible to insert a suitable sized, lubricated catheter into the drainage tube, and, hence, into the common duct. It may be possible, with the use of this type of drain, to introduce cholesterol solvents directly upon a stone in the common bile duct, and thus free the duct from impacted or other gallstones. Many other uses for this modification will suggest themselves to the surgeon who is confronted by obstructions of the common bile duct.

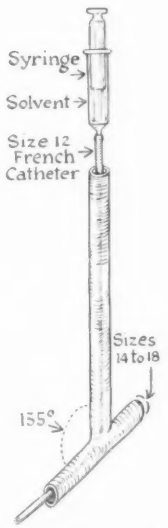

FIG. 1.—"T"-tube catheter. Solvent pushed through catheter inside "T"-tube placed in common duct.

INTRAPERITONEAL SULFANILAMIDE

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PLACING SULFANILAMIDE CRYSTALS in the peritoneal cavity is an application of local chemotherapy which is coming into rather wide use. Accepting the sulfonamide drugs as bacteriostatic, the local use of sulfanilamide in the peritoneal cavity is sound. It may be assumed that the drug, by holding in check bacterial multiplication, en-

ables the efficient defense mechanisms of the peritoneum to overcome contamination which might otherwise prove overwhelming.

The effectiveness of local chemotherapy has been said to be more or less directly proportional to the concentration of the drug, and inversely proportional to the number of organisms. With this thought in mind, investigation of the absorption of sulfanilamide from the peritoneal cavity was undertaken. This was done by collecting repeated blood specimens from patients who had received the drug intraperitoneally and from experimental animals (dogs) to whom the drug had similarly been administered. It was found that the absorption into the blood stream was extremely rapid. With therapeutic amounts, the blood concentration reached a peak in about two hours, and thereafter fell rather rapidly to almost nothing at the end of 24 hours.

It seems from these findings that the absorption of sulfanilamide by the peritoneum is so rapid that its local effect may be so transient as to be relatively unimportant, and that other routes of administration might be just as effective. On the other hand, there seems to be no other way of administering the drug which raises the blood concentration to effective levels so rapidly. Therefore, intraperitoneal administration is a valuable method of obtaining an initial saturation which may later be maintained by oral or parenteral medication.

During the year 1940–1941, 25 patients at the University Hospital received sulfanilamide in the peritoneal cavity. Many of these cases received supplementary intravenous sulfanilamide. The indications for the use of the drug were peritonitis, operations upon the large bowel, and soiling of the peritoneum with the contents of the gastro-intestinal tract. The clinical results were gratifying. No fatalities occurred from peritonitis, except in the cases in which the use of the drug was not continued. Various toxic manifestations, chiefly nausea, were noted. But only one complication stood out and caused concern—and this was jaundice. Six of the 25 patients developed a definite icterus which was felt was due to liver damage, since sepsis and hemoclasis were ruled out. In none of the six patients was the jaundice fatal and it cleared in all instances on discontinuing the drug.

This complication was further checked in the laboratory. Sulfanilamide was placed in the dog's peritoneal cavity and simultaneous blood specimens were taken from the portal and jugular veins. It was found that during the absorptive phase sulfanilamide levels in the portal blood were 30–40 per cent higher than in the jugular blood. Such findings suggested that the jaundice might be due to liver damage, caused by unusually high portal blood levels when the drug is absorbed from the peritoneum.

The peritoneum in the experimental animals showed no evidence of untoward irritation from the local use of the drug.

RESULTS OF CONSERVATIVE TREATMENT OF ACUTE PANCREATITIS

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IN 1936 Dr. George Plain and I studied 26 cases of acute pancreatitis treated at the Henry Ford Hospital, during the 20-year period 1917–1936. Of the eight patients (30.8 per cent) in this group who were diagnosed preoperatively, five were treated by immediate and three by delayed operation. The remaining 19 patients, on whom erroneous diagnoses were made, were operated upon as emergencies. The mortality for the series was 46.1 per cent, a figure that closely approximates the death rate in other collected reports. The finding that almost one-half of our patients died following emergency operations for acute pancreatitis clearly indicated that our method of dealing with these patients should be subjected to a critical review. An outstanding feature of the fatal cases was the relatively short duration of life following operation, for in 75 per cent of patients who died the average postoperative duration of life was only 21 hours. This observation suggested very strongly that the added

insult of the operative procedure had turned the tide against certain patients who might otherwise have survived the attack.

With the encouraging reports of Cole, Elman, Wildegans, Mikkelsen, and others to back our conviction, we decided to abandon immediate operation and adopt the conservative treatment of acute pancreatitis at the Henry Ford Hospital. During the past five years, we have observed 24 cases of acute pancreatitis, and of this group all but three have been treated conservatively. The three patients of the group who were operated upon were all diagnosed preoperatively as acute cholecystitis, and the diagnosis of acute pancreatitis was only made at the operating table. All these patients recovered but none was operated upon during the acute stage of the disease, since it is our present-day practice to defer operation in uncomplicated cases of acute cholecystitis for at least 72 hours. In 11 of the 21 patients treated conservatively, the diagnosis was verified at subsequent operations upon the biliary tract. There was only one death in this series of 21 patients treated conservatively, producing a mortality rate of only 4.8 per cent. Even if the diagnosis of acute pancreatitis is questioned in all the patients on whom the diagnosis was not verified by later operation, the mortality rate would still be only 10 per cent, a figure which contrasts favorably with the mortality rate of 46.1 per cent in our previous series in which immediate operation was performed. On the basis of clinical findings, 16 of the 21 patients (76.2 per cent) were indexed as suffering from severe, and five from mild cases of acute pancreatitis, although admittedly classification is difficult.

The proponents of immediate operation base their contention of the necessity for immediate evacuation of the products of pancreatic disruption on their allegedly necrotizing properties. However, the experimental work of Whipple (1913) and Lewisohn (1940) indicates that this material is more innocuous than was formerly believed. The development and acceptance of the conservative treatment of acute pancreatitis had its origin in the observation that undiagnosed cases of acute pancreatitis usually recovered following drainage of abscesses or pseudocysts.

In the past the great problem of conservative treatment has been the difficulty in making a correct preoperative diagnosis. This problem has been solved to a great extent by routine use of blood diastase estimations in suspected cases. Increased diastatic activity is constant in acute pancreatitis, but determinations must be made early in the attack. The value of this diagnostic procedure is so well-established that elevated blood diastase values must be accepted as definite confirmatory evidence of acute pancreatitis, when the clinical features of the case suggest this diagnosis. The use of this test plus increased interest in the disease has raised the number of correct diagnoses at the Henry Ford Hospital from 33 to 75 per cent.

PHEOCHROMOCYTOMA

A Report of Three Cases

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PHEOCHROMOCYTOMA, or chromaffin cell tumor, is an adenoma arising from the medullary cells (chromaffin cells) of the adrenal gland, or from aberrant chromaffin tissue which may occur along either side of the vertebral column. These tumors are apparently capable of secreting large amounts of adrenalin, which may be thrown into the blood stream at irregular intervals and thus cause typical recurring crises in which paroxysmal hypertension is the outstanding symptom. Other symptoms which have been observed are cardiac palpitation, a slowing or an increase in the pulse rate, pallor, sweating, nausea and vomiting, severe headache, dyspnea, sensation of suffocation, pulmonary edema, convulsions and coma, and glycosuria. A palpable tumor is very rarely found because these tumors are usually small. In long-standing cases the hypertension may become more or less constant and the typical paroxysms disappear. The disease is usually one of early adult life.

Once the condition is clinically suspected,

the diagnosis can usually be proved by roentgenographic studies following the perirenal injection of air, although in a fair percentage of the cases a soft tissue shadow or an area of calcification may be demonstrated in the adrenal region in the ordinary film of that region.

Surgical removal of these tumors has given excellent results. The best approach is probably by means of a bilateral simultaneous exposure of both adrenals. This operation allows the surgeon to be certain that a normal adrenal is present on the other side, and this information is essential before removing the tumorous gland. These tumors have also been removed through the ordinary lumbar incision (as for nephrectomy) and by the transperitoneal route. Practically all of the operative deaths have been due to severe shock and collapse. This usually occurs when the pedicle of the tumor is ligated and can be combated with very large doses of intravenous adrenalin, sufficient to sustain the blood pressure.

Three personal cases were reported in which the clinical diagnosis was made, and proved by perirenal air injections. All three patients were operated upon; in each case the tumor was successfully removed, and an excellent result obtained.

THE SURGICAL TREATMENT OF HYPERTENSION

Preliminary Report of Comparison of Mortality Following Operation with That of a Medically Treated Control Series (Wagener-Keith) Tentative Correlation of Results with Recent Experimental Work

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BILATERAL SUPRADIAPHRAGMATIC SPLANCHNICECTOMY and lower dorsal sympathetic ganglionectomy for the relief of essential hypertension has been performed in over 700 cases at the University Hospital. The operation was introduced in this country by Dr. Max M. Peet, in 1933. Results in 350 consecutive cases were recently reported in detail.[1]

In order to determine the effect of the operation on ultimate mortality, the first 76 consecutive cases operated upon by Doctor Peet were chosen for analysis, because the postoperative period of from five to seven years seemed adequate to fully evaluate the results and because this time-period lent itself to comparative study.

Wagener and Keith[2] recently published the mortality of a medically treated control series of 219 patients suffering from essential hypertension, and who were followed five to nine years from the time of first examination. These patients were classified according to ocular fundus findings into the four groups, originally described by Keith: (Group I) Diffuse arteriolar disease and mild hypertension, who have no definite symptoms, no cardiac or renal failure, whose retinal arterioles exhibit a mild grade of narrowing and chronic sclerosis; (Group II) relatively high blood pressure, with symptoms, whose retinal arterioles show a more marked grade of sclerotic narrowing without angiospasm; (Group III) high blood pressure, definite symptoms, whose retinal arterioles show unmistakable angiospastic narrowing. Also included in this group are those with angiospastic retinitis without measurable papilledema; (Group IV) so-called "malignant hypertension." Measurable papilledema, angiospastic retinitis with varying degrees of chronic sclerosis of the arterioles.

Utilizing the above classification and comparing the mortality of our surgically treated series and the Wagener-Keith medically treated series, the difference in mortality between the two series is clearly demonstrated.

It can clearly be seen from the table below that operation reduced the mortality to a marked extent, especially in Groups III and IV. After five years, 80 per cent of Group III were dead after medical treatment, as against only 33 per cent mortality in the surgical group. Ninety-nine per cent of the patients with malignant hypertension (Group IV) were dead after five years, as compared with a 66.5 per cent mortality in our series.

Since the comparative best results following splanchnicectomy seem to be in those patients with angiospasm of the retinal arterioles, even with papilledema, and the

less satisfactory results in those with arteriolar sclerosis, it would seem that in some way the operation is releasing vasospasm of the arterioles, not only in the ocular fundi but elsewhere in the body, and thus decreasing the peripheral resistance responsible for the increased blood pressure.

effective renal blood flow, or release of efferent glomerular arteriolar spasm, following operation, with a persistent clinical drop in blood pressure. Should such a correlation be found, it would be presumptive evidence that in man, as in the Goldblatt animal, renal ischemia could be a causal

TABLE I

DEATHS WITHIN A GIVEN NUMBER OF YEARS

	Group I		Group II		Group III		Group IV	
No. of Years	Wagener-Keith	Peet	Wagener-Keith	Peet	Wagener-Keith	Peet	Wagener-Keith	Peet
1	10%	0%	12%	33% (1 oper.)	35%	6% (1 oper.)	79%	37.5% (1 oper.)
2	20%	0%	23%	46%	67%	12%	88%	50%
3	30%	0%	38%	46%	78%	21%	94%	62.5%
4	30%	0%	42%	53%	78%	24%	98%	66.5%
5	30%	0%	46%	60%	80%	33%	99%	66.5%

In the laboratory of the Section of Neurosurgery we are measuring (in conjunction with Dr. Piero Foa) effective renal blood flow as measured by diodrast clearances, and glomerular filtration rates by means of inulin clearances. We have been able to corroborate the findings of Dr. Homer Smith that patients with hypertension have, usually, a lower effective renal blood flow than do normal individuals, and that this renal ischemia appears to be due to increased resistance of the efferent glomerular arterioles. This renal ischemia may be either a causal factor in essential hypertension, as in the Goldblatt animal, or merely an aspect of the generalized systemic vascular disease. Experiments are in progress attempting to correlate any increase in factor in essential hypertension and that, therefore, those good results following bilateral splanchnicectomy and lower dorsal sympathetic ganglionectomy in patients having angiospastic narrowing of the retinal arterioles might be due to relief of this renal ischemia and a subsequent decrease in the production of a pressor substance, causing generalized vasospasm and consequent increased peripheral resistance.

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A CRITIQUE OF THE SURGICAL TREATMENT OF HYPERTENSION

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DURING the past seven years about 700 patients have been subjected to bilateral, supradiaphragmatic splanchnic section at the University Hospital. Three hundred and fifty cases operated upon by one man (Peet) have been studied in detail preoperatively, and from nine months to seven years postoperatively by the various departments of the hospital.

Another large series is that of Adson and Craig who have employed a subdiaphragmatic operation, with no postoperative deaths in 271 consecutive cases. Their results are in general comparable to ours, but they have not had as good results in malignant hypertension. This may be due to the fact that theirs is partially a postganglionic procedure.

White and Smithwick have criticized previous operations on the basis that they are either incomplete or do not guarantee against nerve regeneration. They are now carrying out an extensive supra- and transdiaphragmatic procedure. Though it is still too early to say which is best, they have had some excellent results. What is most

important is the fact that three large series of operative cases are being carefully studied by skeptical but competent nonsurgical observers. It is more than ever our opinion that surgery has more to offer real hypertensives than any other form of treatment generally available at this particular moment.

There has been considerable criticism of the surgical treatment of hypertension. Individual cases are quoted of people who lived for years without symptoms from their high blood pressure, but these are exceptions since hypertension kills more people than cancer. Especially is this true in the case of males.

Volini and Flaxman cite 27 cases in which a drop in blood pressure was found following nonspecific operations. Three were operated upon for prostatism, where it is well-known that catheter drainage alone can reduce the elevated blood pressure to normal. Prostatectomy here might be considered a specific operation. In one patient, a thyroidectomy was performed, with a preoperative pressure of 170/120. Two patients, age 49 and 50, had preoperative pressures of 116/110 and 160/110, respectively. With a single reading at this or any other figure, and there is no evidence that more than one reading was taken, one cannot make a diagnosis of essential hypertension. The authors of this article show no series of cases or even individual cases where hemorrhages, exudates, and papilledema have disappeared from the eye-grounds, where heart size and kidney function have returned to normal, and yet they state: "Any of the claims made for the efficacy of treatment of essential hypertension by specific surgical measures can be substantiated by our cases of nonspecific operation." The same argument can be applied to the advocates of psychotherapy, and few patients with malignant hypertension would even survive 18 months of psychoanalysis.

In a recently published article, Rytand and Holman have been unenthusiastic about supradiaphragmatic splanchnic section, after performing it upon 40 patients, in more than half of whom the blood urea and, therefore, the nonprotein nitrogen of the blood was elevated. In the group of six patients in which "the best results followed operation," the blood urea was definitely stated to be normal. Every report by Peet has specifically stated that when the nonprotein nitrogen of the blood is elevated, operation is contraindicated. Rytand and Holman have merely proven this point.

The most valid criticism of the surgical treatment of hypertension is that only slightly more than 40 per cent of operatives show a significant drop in pressure at the time of examination from nine months to seven years postoperative, and that cases which will respond to splanchnic section cannot be selected in advance. The article by Dr. Ward Woods, in this issue, shows that progress is being made in the attempt to rule out those not vasospastic but primarily arteriosclerotic and those with fixed vascular changes, as candidates for splanchnic section, just as routine pyelography in the last three or four years has prevented certain hypertensives with unilateral or bilateral kidney disease from undergoing this operation.

THE RELATION OF HYPERTHYROIDISM TO HYPERTENSION

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FROM A STUDY of 351 unselected cases of hyperthyroidism, it was found that as a physiologic response to hyperthyroidism the systolic blood pressure is usually slightly elevated and recedes to the normal level following surgical remission of the thyrotoxicosis. Furthermore, it was found that the resting systolic blood pressures exceeded the upper physiologic limit of 150 Mm. of mercury in 99 cases (25.3 per cent), 160 Mm. in 65 (19.5 per cent) and 200 Mm. in 13 (3.7 per cent).

In an endeavor to determine the relation of hyperthyroidism to the elevation of blood pressure in these cases, a comparative study of the resting blood pressure levels before, and one year or more after, relief from hyperthyroidism by subtotal thyroidectomy was made in 48 cases available for such follow-up observations. Of the 48 cases, the blood pressures were uninfluenced by relief from hyperthyroidism in 21 and remained either essentially unchanged or continued to increase. But in 27, or a slightly

larger number of cases, the pressures were appreciably reduced following subtotal thyroidectomy, and in 15 they had receded to relatively normal levels.

Thus it appears that clinically two types of cases are discernible:

(1) A type in which hyperthyroidism and an established hypertension coexist, incidentally, in the same person as separate, unrelated entities. Usually the hypertension is essential in type, although its severity apparently is increased by the thyrotoxic state, and some improvement may follow release from hyperthyroidism. Despite symptomatic improvement, however, the blood pressure, both systolic and diastolic, remains high and usually is not significantly lowered, and the disease continues to progress.

(2) A type in which relief of hyperthyroidism by subtotal thyroidectomy causes both the systolic and the diastolic pressure to recede promptly to a much lower or normal, or nearly normal, level at which it remains or from which, after a period of many months, it again gradually ascends. This response suggests that thyrotoxicosis in these cases is either directly responsible for the hypertension or, more likely, precipitates or exaggerates a latent vascular disorder. It is conceivable that an inelastic or restricted vascular bed, capable of receiving the normal cardiac output without appreciable elevation of blood pressure, would be unable to receive the increased output incident to hyperthyroidism without a sharp rise in the propelling force. Conversely, with lessening of the output by remission of hyperthyroidism the pressure required to propel the blood is diminished. In other words, this hypothesis assumes the existence of arteriolar pathologic changes which are insufficient to increase appreciably the resistance to a normal volume of blood flow, but which are sufficient to prevent normal expansion as the load is increased in response to either hyperthyroidism, exercise, or the cold pressor test.

This hypothesis finds support in the response of the seven cases in which large reductions of blood pressure had developed and been sustained after subtotal thyroidectomy. After the basal level of blood pressure had been obtained, each of the seven cases was given sufficient exercise to increase the pulse rate appreciably (from 16 to 40 beats per minute), and the blood pressure was determined immediately afterward, and at subsequent intervals of 60 seconds. In each instance, the pressure rose to the approximate preoperative resting level. Moreover, these levels were sustained abnormally long and receded abnormally slowly. Thus the response of blood pressure to the increased cardiac output incident to exercise was approximately the same as that recorded preoperatively during the thyrotoxic state.

Each case was then subjected to the cold pressor test, described by Hines and Brown. In accordance with their technic, the lowest or basal level of blood pressure was obtained with the subject resting supine for 30 minutes or longer. With the blood pressure cuff in place on one arm, the opposite hand was immersed in ice water (4° C.) to a point just above the wrist for 60 seconds, and readings of blood pressure were made 30 and 60 seconds after the beginning of immersion. Within 30 seconds, the pressure again mounted to approximately the same level which followed exercise. In the light of the studies of Hines and Brown, the reaction of the blood pressure in these patients to the cold pressor test was excessive and abnormal, as is that in all subjects afflicted with essential hypertension. The studies of these investigators showed that in addition to the persons with hypertension there is a group of persons who do not have hypertension but do give excessive reactions to the cold pressor test. Persons in this group they designated "hyperreacting normals," and they stated the belief that this excessive reaction indicates a latent quality and a likelihood of subsequent development of hypertension. On this basis, it may be reasoned that my patients had potential, if not real essential hypertension, and that the latent factor had been precipitated or exaggerated by thyrotoxicosis.

It is interesting that in each of these seven cases there was a familial history of hypertension.

DISCUSSION.—DR. ROY D. MCCLURE (Detroit): I should like to ask Doctor Bisgard whether he noticed any difference in the reduction of blood pressure, or the effect of the blood pressure, in case the hyperthyroidism was due simply to hyperplasia or to an adenoma.

DOCTOR BISGARD (closing): All of these cases were toxic cases, of course, and there was no particular difference in the response of those with toxic adenomata and those with diffuse hyperplasia with toxicosis. Both groups showed the response of a drop in blood pressure, but there was more response in the group with diffuse hyperplasia.

DR. LOUIS G. HERMANN (Cincinnati): I should like to ask Doctor Bisgard how he determines the degree of arterial obliteration in the patients.

DOCTOR BISGARD: I have no notion regarding that. The thought was purely speculative, theorizing in an effort to explain the response to thyroidectomy, exercise, and the cold pressor test. Also the subsequent progress of some cases was typical of essential hypertension. Furthermore there was no evidence of nephritis or other renal disease. Does that answer your question?

DOCTOR HERMANN: Patients with extensive arterial obliteration do not always show hypertension. There is really no evidence to show obliteration of the artery will cause hypertension *per se*. You made that statement, and I wondered how you determined that.

DOCTOR BISGARD: I said in the discussion that I assumed these people probably had arteriolar disease, and that the hypertension was evidence of a restricted vascular bed, and that in relieving the hyperthyroidism the blood pressures receded again because this lessened the load on the vascular bed. This is a purely theoretic conjecture.

"SHORT-INTERVAL" STAGE THYROIDECTOMIES

A Further Report

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THIS STUDY SUPPLEMENTS a report by one of the authors, in 1938, of the satisfactory use of "short-interval" stage thyroidectomies as a means of carrying poor-risk patients safely through the dangers of thyroid surgery, and at the same time avoiding the economic handicaps of prolonged preoperative hospitalization or of a long interval of invalidism between stages. It adds data on 38 patients to the 161 cases previously reported. Table I shows, comparatively, the statistics on hospitalization of the two series. It will be seen from this table that the average total days in hospital has been lowered by three, and the average number of days between stages, and after the second stage, each lessened by one day.

TABLE I

DURATION OF HOSPITALIZATION

	161 Pts. 1924–1936	38 Pts. 1937–1940	25 of 38 Pts. 1937–1940	13 Thyrocardiacs 1937–1940
Av. no. of days before operation	12.9	15.5	9.2	22.1
Av. no. of days between stages	8.8	7.9		
Av. no. of days after second stage	10.5	7.7		
Av. no. of total days in hospital	32.2	29.6		

Thirty-one of the 38 patients were severely hyperthyroid. A less severe, though marked degree, of hyperthyroidism in the seven others was complicated by myocardial damage, arterial hypertension, diabetes, or advanced age.

Table II details postoperative complications. The one death from a thyroid crisis and pneumonia was in a male, age 48, with severe hyperthyroidism, diabetes, and nephritis. It represents a marked improvement in operative mortality (2.6 per cent) over that of the previously reported series (7.5 per cent). Five other patients survived thyroid crises, largely, we believe, through the prompt employment of an oxygen tent. The incidence of wound infection in this series is, likewise, but half that of the previous series. Two of the three infections were trivial and brief, one appearing three months after operation. The third was slight but prolonged. In all three, a drain was used, and in 17, consecutive, recent patients whose wounds were closed without drainage, no infection has occurred. Even though three of the five postoperative vocal cord paralyses are known to have been transient, this complication continues to disturb us. In all five patients, the thyroid gland at operation was diffusely hyperplastic, large, tough, and with a well-developed extension of the midportion of the lobe into the tracheo-esophageal sulcus. Since every one of these five patients became more or less hypothyroid after operation, we probably injured these nerves by trying too hard to perform a very thorough resection.

TABLE II

EARLY POSTOPERATIVE COMPLICATIONS

	After 1st Stage	After 2nd Stage	Percentage
Death	0	1	2.6
Crises	3	2	13.1
Fibrillation	3	0	8.1
Infection	0	3	8.1
Laryngeal nerve injury*	2	3	13.1*
Hemorrhage	0	0	0.0
Tetany	0	0	0.0

* All unilateral—three known recoveries.

Table III gives the end-results of this series. Unless we had been able to follow such a large number currently, the cases would not have been reported. The fact that all patients gained early relief from

TABLE III

END-RESULTS

No. of patients followed currently	32 of 37	86.4%
No. of patients followed over one year	35 of 37	91.1%
Recurrently or persistently hyperthyroid	0 of 37	0.0%
Persistently hypothyroid	12 of 37	33.0%
Recovery from vocal cord paralysis	3 of 5	60.0%
Recovery from auricular fibrillation	5 of 7	71.4%
High pulse pressure remedied	15 of 28	53.5%
Good scar	30 of 37	81.8%
Fair scar	4 of 37	10.8%
Poor scar—all keloids—all colored	3 of 37	8.2%

their hyperthyroidism; that there were no recurrences among those followed; that only one-third showed any degree at all of hyperthyroidism; that there was no case of tetany, and but one death, confirms us in continued advocacy of "short-interval" stage thyroidectomies for severe or otherwise complicated hyperthyroidism, preferably two separate subtotal lobectomies, spaced seven to nine days apart.

DISCUSSION.—DR. W. A. ALTEMEIER (Cincinnati, Ohio): I should like to ask Doctor McGraw how he decides a patient is a candidate for the "short-interval" stage thyroidectomy, whether at the preliminary examination, after the preoperative rest period, or upon the operating table.

DOCTOR MCGRAW: I would say, usually, we make the decision when we first see the patients, if we see them at the time of their admission to the hospital, which, unfortunately, we do not always have the opportunity of doing.

If we do not make the decision then, we are sometimes led to the decision in the case of patients whose general clinical response, and particularly the response of their basal metabolic rate, does not materially alter during their hospital stay, even though the metabolic rate may not necessarily have been extremely high at the beginning. In other words, the drop of metabolic rate, we will say, from plus 75 to plus 45 or 50 per cent I think is more an indication for complete operation than the failure of a metabolic rate of, say, 50 per cent to drop below 45 per cent after a stay of ten or 12 days in the hospital.

In the third place, there are, of course, some patients in whom we are led to resort to stage operations at the operating table, when they surprise us by obviously doing worse under the operation than we had expected them to do.

DR. ROY D. MCCLURE (Detroit): There are two questions I should like to ask Doctor McGraw. He did not mention whether the nerve injuries were temporary or permament, whether it was simply a stretching of the nerve or cutting.

DOCTOR MCGRAW: Three of the five injuries we had recovered. They were apparently only stretchings of the nerve. The other two are among the patients we have thus far been unable to trace, so I would not be able to answer that question until next year. I suspect that these two have not recovered.

DR. GEORGE M. CURTIS (Columbus, Ohio): I should like to ask Doctor McGraw if he has used a high calcium diet and vitamin D in preparing his patients for thyroidectomy.

DOCTOR MCGRAW: We have used vitamin D to some extent, but not a great deal.

DR. J. DEWEY BISGARD (Omaha, Nebr.): I should like to ask Doctor McGraw if he has used roentgenotherapy as a preliminary step in these bad-risk cases, and what his opinion may be regarding that.

DOCTOR MCGRAW: Our own opinion to date is that roentgenotherapy not only is not a curative agent but is of very little help in preparing these patients. It was administered rather thoroughly in one of the patients in this last series. It is a matter of speculation, but it was my impression that this patient's very long period of rest in the hospital, 72 days, had certainly as much, if not more, to do with our being able to operate upon her at all, than such roentgenotherapy as she had undergone.

EXPERIMENTAL AND CLINICAL OBSERVATIONS ON THE SYNDROME OF PINEAL GLAND DESTRUCTION

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THOUGH A LARGE VOLUME of experimental and clinical data is at hand concerning the physiologic action of the pineal gland, there is no common agreement as to the actual rôle this organ plays in the mammalian organism. The present investigation, which has been in progress for more than five years, was prompted by three factors: (1) The existing disagreement among comparative anatomists concerning the evolutional implications of the pineal region of the brain; (2) the lack of agreement as to the exact histologic structure of the pineal gland, and the potentialities of function dependent upon its structure; (3) the possible endocrinic significance of pineal tumors in young human subjects so far as sexual and somatic development are concerned.

The results here reported were obtained following extirpation of the pineal gland from the brains of immature rats, cats, dogs, and monkeys. Litter-mate controls were used for each sex, operations and laboratory conditions were standardized, weight, length, roentgenographic and photographic data were secured at regular intervals, behavior and reproductive characteristics were recorded, and all autopsy material has been subjected to histologic study. The gland was removed from kittens six weeks old by means of the Horsley-Clarke stereotaxic instrument. In all the other animals the gland was removed manually by "open" operation—in the rats at 18 days, in the dogs at five weeks, and in the monkeys at two and one-half months. To date 57 rats, 125 cats, ten dogs and five monkeys have been used in this study.

There was apparently some hastening of maturity in the pinealectomized rats compared to their controls, but our data of this animal have not led to positive conclusions. The results in the cats have been striking in that the pinealectomized males showed a maturity, both in sexual and somatic development, for to five months in advance of that seen in their control littermates. No somatic differences were noted in the female cats, but the pinealectomized females were late in their first estrus, litters were small and frequently dropped before term or born dead, and second generation cats were reared with great difficulty. Somatic and sexual maturity in the pinealectomized male dogs also preceded that of the control animals, and, again, as in the cats, the first estrus occurred later in the pinealectomized female dogs than it did in their normal controls. Complete data concerning the growth, sexual maturation, and histologic findings in the monkeys are not yet available. No degeneration has been found in the fiber tracts leading from the region of the pineal gland in our lesion animals, and no significant histologic changes have been noted in the endocrine organs.

Briefly, these results obtained in the experimental laboratory coincide in what must be more than an accidental manner with an analysis of a large series of patients with tumors of the pineal gland, reported elsewhere by the author. A tendency to somatic and sexual precocity in prepuberal boys with pineal tumors, and amenorrhea in postpuberal girls of otherwise normal development indicate, when considered together with these results of simple *apinealism* in animals, that the pineal gland may be postulated to bear significance as an endocrine organ, related to the processes of sexual and somatic maturation in mammals.

DIAGNOSIS AND TREATMENT OF GLOSSOPHARYNGEAL NEURALGIA

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GLOSSOPHARYNGEAL NEURALGIA is a major type of neuralgia occurring in the distribution of the ninth cranial nerve. The curative treatment has been well-established

since publication of Adson's paper on "The Surgical Treatment of Glossopharyngeal Neuralgia," in 1924.

The symptoms of glossopharyngeal neuralgia are fully as typical as those of trigeminal neuralgia. The severe pain occurs in paroxysms, and between attacks the patient is comfortable and able to go about his normal activities without discomfort. The paroxysms are sudden in onset, and the pain, which usually extends from the region of the tonsillar fossa of the affected side to the homolateral ear, is exquisite. During an attack, the patient usually becomes immobile and is unable to talk, chew, or swallow until the paroxysm has disappeared. Immediately thereafter, he may appear to be perfectly normal and in good health unless considerable loss of weight has resulted from his inability to eat. The paroxysms usually are brought on by chewing, swallowing, and yawning. The examiner may produce an attack by irritating the "trigger zone" in the tonsillar fossa of the side affected. Results of neurologic examination are negative and the pharynx and larynx are free from objective evidence of disease.

Glossopharyngeal neuralgia must be distinguished from trigeminal neuralgia, superior laryngeal neuralgia, and the so-called "atypical neuralgias" of the face and neck. In doubtful cases, the differential diagnosis can be established by cocainization of the throat of the patient on the side involved. This anesthetizes the "trigger zone" of glossopharyngeal neuralgia, and during the period of anesthesia, the patient will be free of paroxysms of pain, so that the examiner will be unable to initiate an attack by irritation of the tonsillar fossa.

There is no specific medical treatment for glossopharyngeal neuralgia. The treatment of choice, and the one which produces excellent results, is intracranial section of the involved ninth cranial nerve in advance of the point at which it enters the jugular foramen. This operation can be performed with little risk through unilateral suboccipital craniotomy. The operation has no distressing sequelae.

DISCUSSION.—DR. HENRY J. VANDENBERG (Grand Rapids, Mich.): I should like to ask Doctor Love if he had used vitamin B at all, vitamin B compound, and vitamin B_1, for these glossopharyngeal neuralgias.

DR. J. G. LOVE (Rochester, Minn., closing): I have had no experience whatsoever with the use of the vitamin compound in glossopharyngeal neuralgia. I have not even tried it for trigeminal neuralgia, but I have had the pleasure of seeing quite a number of patients who had taken such medication without any benefit to trigeminal neuralgia, despite the reports in the literature that it is of distinct benefit.

THE USE OF CELLULOID PLATE TO COVER SKULL DEFECTS: CASE REPORTS

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According to Grekov, Jacob von Mackren, in 1670, successfully repaired a skull defect with a piece of dog's bone. Since then, from time to time, reports have appeared advocating the use of many and various substances to cover skull defects of all types.

All seem generally agreed upon the main indications for plastic repair of skull defects—as follows: (1) to remove the irritation in focal epilepsy; (2) to prevent injury to the unprotected brain; (3) to correct unsightly depressions; and (4) to relieve pain or discomfort resulting from the defects.

The following have been the commonest substances used: (1) Metals—aluminum, gold, silver, and platinum; (2) celluloid and vulcanite; (3) dead bones—obtained from cadavers, dogs, sheep, geese, and oxen; and (4) human bone transplants—usually autogenous from skull, tibia, ribs, ilium, sternum, scapula, cartilage and bone chips.

The important requisites for a satisfactory defect-closing substance are: (1) That it be sufficiently thin and yet possess enough

rigidity; (2) that it have the proper convexity to match the defect; (3) that it be nonirritating to the adjacent tissues; and (4) that it become strongly incorporated in its bed and remain sufficiently rigid after time has passed.

Of the above-mentioned substances, all have their advantages, but also distinct disadvantages. The osteoperiosteal skull grafts (König-Müller, 1890) are probably the best for small defects up to 5 cm. in diameter. Autogenous bone grafts, split ribs and ilium, seem to be preferred by some. There are still some advocates of celluloid plate, even though there have been some unfavorable cases reported. Vitallium, or some metal not too rigid to mold to the proper shape and size, might prove of value in covering the larger defects.

We formerly preferred celluloid for the larger defects because it was the easily available, seemed the simplest to apply, and met all the requisites, except possibly that of irritation of tissues, as in some of our cases repeated aspirations were necessary for several weeks to remove a serous fluid which accumulated.

In order to use a heavier celluloid plate, of 2 Mm. thickness, for greater rigidity than that commonly used, we had made a mold (Fig. 1) with which we have pressed

FIG. 1.—Molding apparatus which presses a piece of celluloid plate to the desired contour. Molded while hot, the whole is sterilized in steam and kept sterile until the operation.

into concave form pieces of celluloid capable of covering more than a complete half of a skull, as we did with the case herewith reported. These pieces were molded and sterilized before the operation, were easily fastened in the gutter, and cut at the margin of the skull defect. The celluloid not only took less space than split ribs or bone grafts, but was stronger and remained so as time passed. In one case, a large wrench fell 20 feet, striking the scalp over a large repaired defect without depressing or cracking the celluloid plate.

We have used celluloid plate in 15 patients. Of these, four had to be subsequently removed. Of these four, one was inserted too soon (six months) after an osteomyelitis, and had to be removed because of subsequent sepsis; another became secondarily infected 16 months later; a third was removed four years later for inspection because of persisting epilepsy, but finding little, was reinserted; the fourth was the case herewith reported, removed after six years. The others have remained apparently perfectly satisfactory for from two to seven years.

The case herewith reported has had several interesting features and illustrates the chief disadvantage of celluloid as a substance to cover cranial defects.

Case Report.—J. R., male, age 30, came to the Henry Ford Hospital, November 22, 1934, because of a hornlike projection from his right forehead (Fig. 2), which interfered with his job as a chauffeur. On

FIG. 2.—Showing an osteoma of skull in the right parietal region.

December 6, 1934, a large osteoma of the skull was removed (Fig. 3) and a previously prepared celluloid plate, 24x9 cm. in size, was inserted. Several aspirations of yellow, serous, sterile fluid were made during the convalescence, but on December 24, 1934 he was discharged as cured, and was very pleased with the result (Fig. 4). He was not seen again for more than two years. He then returned complaining of some tenderness in his occipital region in the midline. Local and roentgenologic examinations showed nothing abnormal. There was a definite reduction in the size of the skull defect, as seen roentgenologically, apparently by new bone formation which had grown out from the margins underneath the celluloid plate.

Four years later, October 16, 1940, he returned complaining of more pain and tenderness in the same region. He also experienced the sensation of fluid running underneath the plate when he tipped his head. There was noticeable enlargement of his head in the lower regions under the old defect.

On October 29, 1940, even though roentgenograms did not show any changes, the gins of the old bone defect. In some places, this had grown outward for a distance of 10–15 Mm. Elsewhere, the dura was thickened to 5–7 Mm., and felt almost as firm as membranous bone. The celluloid plate had been split up into many blisterlike pockets (Fig. 5), filled with a thin, purulent-looking fluid, which cultured staphylococcus. Because of all this evidence of chronic irritation and even of

FIG. 3.—Showing the osteoma of skull removed. A wide removal was made because the skull seemed obnormally thickened in places beyond the limits of the tumor.

area was reexplored. We found the scalp appearing normal, except for a marked thickening from 14 to 17 Mm. In addition to this a layer of fibrous tissue, which was from 5 to 7 Mm. thick, surrounded the celluloid plate and firmly embedded its infection, inasmuch as the defect now appeared to be adequately protected, the plate was left out and the skin was closed with a temporary wick drain. The wound healed cleanly, without any evidence of infection, and when seen, November 18,

FIG. 4.—Two weeks postoperative.

edges. This plate was removed after cutting it free of this encircling ring. Under the plate there was definite outgrowth of membranous type of bone from the mar-

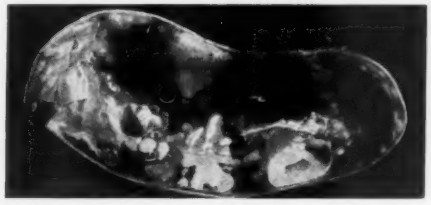

FIG. 5.—The removed celluloid plate.

1940, the defect felt firm and fairly safe against possible trauma. A letter from him, January 3, 1941, stated that he was perfectly well and had no complaints (Figs 6 and 7).

SUMMARY.—We have described a method of using heavy celluloid plate for larger defects, which can be sterilized in de-

FIG. 6.

FIG. 7.

FIGS. 6 and 7.—The patient two weeks after removal of the celluloid plate.

sired size and accurate contour, and we have reported 15 cases where this celluloid plate was used to cover skull defects. Of these, four were subsequently removed, three because of subsequent infection, probably from the repeated aspirations which were necessary. One of these cases, reported in detail, showed such a marked reaction, either from the chronic irritation of the celluloid, or from a low-grade infection, or both, that it was necessary to remove the plate after six years. In the meantime, in this case, the large defect had become quite adequately protected by membranous bone growing out from the margins and by reenforced dura in the center, so that the plate could safely be removed without the danger of trauma or of a subsequent disfigurement. Organisms had been apparently present all this time without any external evidence of sepsis, and after the removal of the plate, the wound healed without evidence of infection. It is to be hoped that Vitallium, or preferably a more malleable material which is nonirritating, can be given a trial, as it would have most of the advantages of celluloid without its disadvantage of chronic irritation.

A REVIEW OF FIFTEEN YEARS' EXPERIENCE WITH EMPYEMA IN INFANTS AND CHILDREN

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THIS REPORT supplements a previous ten-year study of empyema in infants and children published in the ANNALS OF SURGERY, October, 1936. In reviewing our experience with empyema in infants and children during the past 15 years, one is impressed by the number of variable factors influencing the morbidity and mortality. The most important factors are: (1) Virulence of the organism; (2) age of the patient; (3) specific therapy in the treatment of the preceding pneumonia; (4) choice of surgical type of drainage; (5) complications of empyema.

During the period 1926–1936, 407 patients required surgical drainage. The closed-catheter type of drainage was employed, with later conversion to open intercostal drainage. Of this number, 15 later required rib resection and open drainage before a satisfactory result was obtained. The average mortality of this group of 407 patients was 10.3 per cent.

In the period 1936–1941, an additional 144 patients were treated. The cultures of the pleural fluid in this group were: Pneumococcus 74.2 per cent; Streptococcus 10.7 per cent; Staphylococcus 6.2 per cent; no growth 8 per cent; and influenza, 0.9 per cent.

It has been emphasized by Heuer, Graham, and others that there exists a defi-

nite parallelism of the mortality of pneumonia and empyema. This fact is demonstrated in Table I.

TABLE I

MORTALITY PERCENTAGE OF PNEUMONIA AND EMPYEMA

Year	No. of Patients		Per Cent Mortality
1936	Pneumonia . .	697	29.7
	Empyema . . .	35	8.6
1937	Pneumonia . .	962	15.5
	Empyema . . .	34	0.0
1938	Pneumonia . .	921	14.9
	Empyema . . .	29	0.0
1939	Pneumonia . .	1,125	11.6
	Empyema . . .	27	0.0
1940	Pneumonia . .	1,174	6.5
	Empyema . . .	16	0.0

The mortality of pneumonia during the past four years has been progressively lower because of two factors: (1) Decreased virulence of the organism; (2) introduction and extensive use of chemotherapy and serum.

Carey and Cooley, from this hospital, in 1939, reported 630 patients treated for pneumonia during the period, December 1, 1938 to June 1, 1939. Of this group of patients, 248 received sulfapyridine, 106 specific serum, and 276 no specific treatment. Their studies showed: (1) The use of sulfapyridine and serum apparently reduced the total duration of the pneumonia and the mortality rate; (2) specific treatment reduced the number of complications of pneumococcus pneumonia, such as suppurative otitis media, mastoiditis and meningitis.

Carey, in 1940, reported 462 patients treated by chemotherapy alone. Twenty-one showed a leukocyte count under 6,000, before therapy was started. The response was as good as in patients with higher initial counts. All recovered. Significantly, *no patient developed empyema* after entry to the hospital under treatment with sulfapyridine or sulfathiazole alone or combined with pneumococcus serum.

The types of surgical drainage employed during the period 1936–1941 are detailed in Table II.

TABLE II

TYPES OF SURGICAL DRAINAGE EMPLOYED

No. of Patients	Surgical Procedure
141	10—Aspiration (one bilateral)
	40—Closed
	63—Closed and open (intercostal)
	15—Closed (subsequent rib resection)
3	Classified as chronic
	1—Rib resection
	2—Rib resection and packing of cavity
Total 144 (2.1% average mortality)	

During this five-year period, there were two instances of putrid empyema, due to rupture of a lung abscess into the pleural cavity. Primary rib resection was carried out with recovery.

Of the ten patients treated by aspiration, five received chemotherapy after a true pleural abscess or empyema had developed. We have noted no decrease in the necessity for adequate surgical drainage, even though chemotherapy has been given in adequate dosage.

CONCLUSIONS

(1) There is an apparent parallelism of the mortality of pneumonia and empyema.

(2) Chemotherapy and specific serum plays an important rôle in lowering the morbidity, mortality, and complications of pneumonia and empyema in infants and children.

(3) Chemotherapy aids in controlling the toxemia of empyema but does not lessen the need for adequate surgical drainage.

(4) The choice of type of surgical drainage influences the morbidity and mortality of empyema.

(5) Chemotherapy may mask the presence of empyema unless each individual patient is followed by careful roentgenologic studies.

(6) Individualization of the infant or child ill with empyema is important in minimizing the morbidity and mortality.

(7) 551 infants and children were treated for empyema, with an average mortality of 8.2 per cent.

(8) 10,750 infants and children were classified as having pneumonia, and 551 patients developed empyema, an incidence of 5.2 per cent.

DISCUSSION.—DR. J. K. BERMAN (Indianapolis): I should like to ask a question of Doctor Benson, concerning empyemata in children. What does he use as the criterion as to when to operate upon the chest? At the Riley Hospital, in Indianapolis, we have had a good deal of experience with empyemata, and the old criteria were not found satisfactory. We have used the fluoroscope and have found it to be helpful, but I should like to know if he has other aids in deciding when to operate. That seems to be the important thing.

DR. CLIFFORD D. BENSON (Detroit): First, I would like to say that as far as closed drainage is concerned, we have never

had any laboratory guide, but when there is pus of the so-called pea-soup consistency, we have felt we can go ahead and undertake closed drainage safely.

Later on, as far as the time-period is concerned, 15 or 18 days after the onset of empyema, when there is a great deal of fibrin, we feel the child can stand open drainage. One can, by determining the specific gravity of the pleural fluid, feel rather secure in instituting open drainage when the specific gravity of the empyema fluid reaches 1.040. This has been discussed in an excellent article by Pearse. At the time closed drainage is established, the specific gravity of the fluid is about 1.020. That has been a guide of late. Previously, it has been determined merely on the matter of time and character of the fluid and the amount of fibrin present.

DR. LEON J. LEAHY (Buffalo): I should like to ask Doctor Benson if he has noticed any delayed fibrin formation in the pneumonics under intensive chemotherapy treatment, but with a rather good blood level.

DOCTOR BENSON: I have not noticed anything of that type, but Doctor Carey who has been following these patients with us feels that the exudate becomes thicker when chemotherapy is employed.

We have had so few cases during the last two or three years it is difficult to determine this point. The empyema incidence has lowered markedly during the past year. In 1940 we had only 16 patients, and chemotherapy has been used extensively only during the last two years. During the last four years, with various types of treatment, and no standardized treatment, we have now had 106 consecutive patients, with no mortality.

Formerly during the first ten years, most of the patients were treated with closed and open drainage, and very few had rib resection. I think it is an important point that during the last five years we have performed more rib resections. When one analyzes the hospital stay, it has been reduced from 48 days to 38 days. I think their entire recovery has been more rapid because of rib resection and adequate drainage.

PULMONARY EMBOLISM: CLINICAL AND EXPERIMENTAL

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VENOUS THROMBOSIS is the fundamental problem in any discussion of pulmonary embolism. In a consideration of the causes of venous thrombosis, such as retarded circulation, altered metabolism, blood changes, tissue trauma, infection, vessel wall changes, obesity, and age, it appears that the fundamental etiologic factor is retardation of the circulation.

Postoperative inactivity is one of the contributing causes of retarded venous circulation. The supine position, lowered postoperative blood pressure, increased intra-abdominal pressure due to distention and tight binders, dehydration, low food intake, and depressing drugs all contribute directly to venous stagnation.

On the basis of deductive reasoning and experimental work on dogs, in which it was shown that deep breathing, muscular contraction and elevation of the legs produced a marked change in the rate of blood flow in the inferior vena cava, it was concluded that regular postoperative exercises might be of value in preventing postoperative thrombosis. This conclusion is supported by the observations of many earlier clinicians.

The following order, taking effect the morning after operation, was written for all adults capable of cooperating. *Have the patient take 15 deep breaths each morning and each evening, and with each deep breath actively flex the legs.* It was assumed that the deep breathing would tend to aspirate the blood from the pelvic basin, that contraction of the leg muscles would force the stagnant blood out of the muscles into the circulation, and that elevation of the knees during flexion would temporarily increase the amount of blood flow through the femoral and pelvic veins.

Pulmonary embolism is so erratic in its incidence that one may easily be led astray in the evaluation of therapeutic procedures. However, during the 13-year period in which this regimen has been carried out, no case of pulmonary embolism or thrombophlebitis occurred in 728 patients who underwent major surgical procedures and carried out the above exercises. During this same period there were 112 adult patients

with fractures of the tibia, patella, femur, pelvis, and spine who served as controls. All were confined to bed with one or both legs completely immobilized in plaster or in traction. In this group, there were five cases of thrombophlebitis, four of which were followed by pulmonary infarction, and one case of pulmonary embolism, found at postmortem examination, in a man who died five days after fracture-dislocation of the first lumbar vertebra complicated by transection of the cord.

It appears that postoperative breathing and leg exercises, methodically carried out, are of some value in preventing postoperative thrombosis and embolism. I have seen no harm result from this regimen and believe, although I have no statistics at present to support it, that postoperative pulmonary complications are lessened. Patients who have carried out these exercises feel stronger when they get up, and are more rapidly rehabilitated. A much larger series for comparison will be of interest.

HEPARIN ADMINISTRATION

Methods and Results in Thirty Cases

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THIRTY PATIENTS have been treated by general heparinization during a two-year period. The indications were as follows: (1) Postoperative embolism, which was not immediately fatal, 24 cases; (2) embolism of a peripheral artery, with embolectomy, three cases; (3) luetic thrombosis of the posterior tibial artery, one case; (4) hemiplegia from occlusion of the common carotid artery, one case; and (5) phlebitis, one case.

The general plan of heparin treatment is to increase the clotting time of the blood to an arbitrary optimum level, in the hope that dangerous clotting may be inhibited. The usual method is to give the material in a continuous intravenous drip, adding the required amount of heparin to normal saline. Two brands of heparin have been found to be suitable for use in clinical cases over extended periods of time. These are (1) Liquaemin (Roche-Organon, Inc.) and (2) Solution of Heparin (Connaught Laboratories, University of Toronto). Each of these brands of heparin is sold in 10 cc. vials containing 100 mg. of the crystalline salt. It is convenient to add one of these vials to 500 cc. of normal saline for intravenous administration.

The commonly accepted optimum level to which the clotting time is elevated is one that is three times the normal. If the capillary tube method is used, the latter value is about 15 minutes. If the test tube method is used, the value is 25 to 30 minutes.

The amount of heparin solution necessary to produce the desired change in the clotting time will vary greatly from patient to patient, and sometimes from day to day in the same patient. Chart 1 shows what might be termed an ideal heparin chart, with the clotting time being kept at approximately 15 minutes (capillary blood in capillary tubes) by the administration of slightly more than 1,000 units of Connaught Heparin per hour.

The results from heparin treatment have been satisfactory in a general way. Twenty-two of the 24 patients with postoperative embolism recovered. Of the two fatalities, one patient apparently represents an instance of a second embolism after one week of heparin treatment. The other death appeared to be due to a combination of the original large infarct and cardiac failure. The circulation was restored in two of the three peripheral embolectomy patients; the third expired shortly after the attempted removal of clots from the iliac artery. A case each, of phlebitis and arterial thrombosis, was benefited by heparin treatment. One patient with hemiplegia was not favorably affected by heparin.

There were four instances of hemorrhage from the operative wound, two of these being from the popliteal wounds made in performing an arterial embolectomy. Four days had elapsed in each case, and although the heparin had to be discontinued, the arteries remained patent. The third patient bled from the wound made during

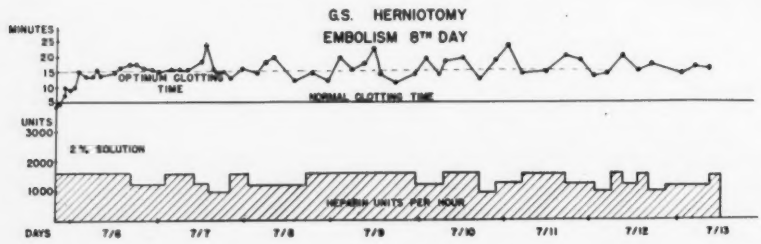

CHART 1.—Heparin chart of a patient showing a good response to the administration of 1,000 units of heparin (10 mg.) per hour. The clotting time was maintained at a level of about 15 minutes (capillary tube method).

the dissection of an abdominal wall sinus, and the fourth bled from the vagina following total hysterectomy. There was one instance of concealed bleeding into the subcutaneous tissues of the leg. A low blood ascorbic acid level was present (0.20 mg.).

In spite of the complications described, it is felt that heparin is of great value in the treatment of thrombo-embolic manifestations and in arterial surgery.

MEDIASTINAL CYSTS

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UNDER the classification of mediastinal cysts different authors have included pulmonary diverticula, pseudocysts, and pulmonary, esophageal, and cardiac herniations. Since a sufficient number of mediastinal cysts have been reported, a classification is suggested which would materially assist future cataloging of reports.

CLASSIFICATION

(I) Parasitic cysts—ecchinococcic cyst
(II) Cysts derived from original germ layers
  (a) Dermoid and teratomatous cysts
  (b) Branchial cysts
    (1) Simple branchial cysts
    (2) Branchial cysts containing respiratory tract elements
    (3) Branchial cysts containing gastro-intestinal elements
    (4) Branchial cysts containing a combination of elements of the above three
  (c) Cystic lymphangiomata
(III) Cysts originating independently from pathologic processes
  (a) Venous cysts
  (b) Pericardial cysts (pericardial and bronchial diverticula or herniations should not be included)
  (c) Simple serous cysts

Ecchinococcic, dermoid, and teratomatous cysts have been fully discussed in the literature.

Branchial cysts assume any one of four forms. The first resembles the branchial cyst seen in the cervical region which is lined by either stratified squamous, columnar, or ciliated epithelium and which contains mucoid material and cholesterol. The second contains elements of the tracheobronchial tree. The third simulates the gastro-intestinal tract, some cases appearing like esophagus and others like the stomach. The fourth group contains a combination of the above elements. The cysts do not communicate with any viscus and originate in the region of the tracheal bifurcation.

Cystic lymphangiomata occur in any portion of the mediastinum and are similar to those found in the posterior cervical triangle.

Vascular cysts are rare but in every instance have been found in the superior mediastinum in close relation to the great

veins. Their pathogenesis is difficult to determine and most observers believe they are due to congenital venous aneurysms undergoing inflammatory occlusion of their ostia.

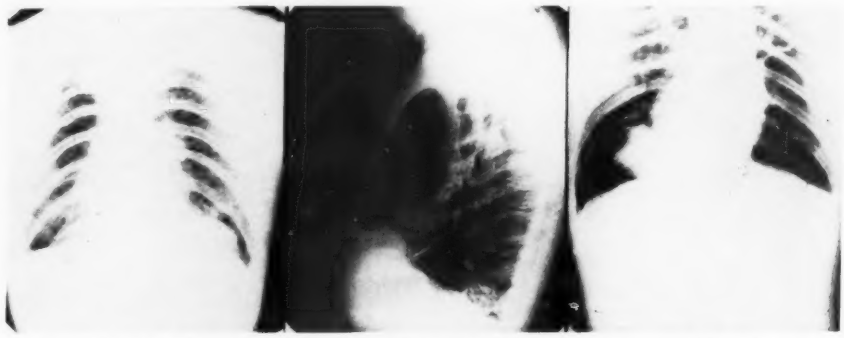

FIG. 1a.—AP view shows tumor mass at cardiac apex.

FIG. 1b.—Lateral view with pneumothorax showing tumor in anterior mediastinum.

FIG. 1c.—AP view with pneumothorax shows tumor attached to pericardium but not to pleura or diaphragm.

Pericardial and bronchial diverticula and herniations are not true cysts and therefore should not be included in the classification. A complete study of the literature was undertaken to rule out possible occlusion of their ostia by inflammatory processes. In only one case out of 45 was a closure of the opening found.

Eliaschewitz has reported the only intrapericardial cyst.

The literature reveals three reports on simple serous cysts. The report of our case is as follows:

CASE REPORT.—W. F., male, age 39, was admitted to the Wisconsin General Hospital complaining of abdominal pain of two months' duration and characterized by sudden sharp attacks followed by vomiting. Remainder of his history and the physical examination were essentially negative.

Roentgenologic studies of his gastro-intestinal tract showed a 5 cm. tumor immediately adjacent to the cardiac apex. Pneumothorax (Fig. 1c) showed the mass distinctly rounded and attached only to the pericardium. Lateral film (Fig. 1b) placed the tumor in the anterior mediastinum.

Exploratory thoracotomy revealed a cystic tumor (Fig. 2) which was readily peeled from the pericardium. Postoperative course was uneventful.

COMMENT.—If Lambert's theory, that these cysts result from embryologic rests, is correct, then these cysts should be classified under "cysts derived from original germ layers."

These cysts differ from pericardial diverticula, in that they arise on the left side of the pericardium and produce symptoms related to the gastro-intestinal tract. In contrast, pericardial cysts occur on the right side and produce symptoms related to compression of the bronchus.

Jenssen's test, presumably pathognomonic for pericardial diverticula was not carried out in our case. The repetition of it would have shown if a cystic mass is influenced by this test.

FIG. 2.—Photograph of tumor.

Artificial pneumothorax produced a more rounded change in the shape of the shadow, indicating this was a fluid-like mass. It also showed that the tumor was attached only to the pericardium.

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A METHOD FOR PLASMA PREPARATION AND PRESERVATION FOR INTRAVENOUS USE

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PRESERVED BLOOD PLASMA has been repeatedly demonstrated to be an efficacious therapeutic agent in conditions where its use is indicated. These conditions may be roughly grouped under three general headings: (1) Decreased blood volume;[3, 5, 6, 10] (2) hypoproteinemia,[7, 11] (3) inadequate immunity;[3, 4] the efficacy of plasma in these instances largely rests upon its protein constituents—albumin, globulin, fibrinogen, and is intimately related to the functions which these protein fractions perform in the body. Among the most important of the functions of the plasma protein from the clinical standpoint are: Control of fluid exchange between circulating blood and tissues; maintenance of blood viscosity; clotting of the blood; protein reserve; and antibody formation. It is significant that properly prepared and preserved the plasma proteins retain these important properties over considerable periods.[8] Studies in preparation and preservation of plasma for therapeutic use have revealed in addition to the stability of its protein fraction two outstanding advantages possessed by preserved plasma over preserved whole blood: No typing or cross-matching is required preliminary to its employment and it can be administered with marked therapeutic effect after much longer periods than preserved whole blood. Both of these advantages arise from the removal of agglutination and hemolysis factors which are avoided by removal of the cells.[9]

The requirements for preparation of plasma are: Absolute sterility; freedom from physical agents acting as emboli; ease of technic. The method herein described[1, 2] has proven satisfactory in these respects. The essential part of the procedure consists of a glass tube, consisting of an upper and lower chamber with a narrow hollow connecting piece between, and a neck of the same narrow caliber connected with the upper chamber. The upper chamber and connecting piece contain 50 per cent of the filled volume and the lower chamber the remaining 50 per cent. Blood from a suitable donor is taken in the sterilized tubes under sterile technic through a long, large caliber needle fitting into the lower chamber containing the anticoagulant. When filled the needle is removed and the open neck fire-sealed. The tube is centrifuged at 1000 for 20 minutes at the end of which time the plasma has separated into the upper chamber and connecting piece. At this point the juncture of the connecting piece is scored with a file and the lower chamber containing the cells is cracked off and the open end of the connecting piece fire-sealed. The result is an hermetically sealed glass ampule of plasma from which the plasma is easily evacuated.

A modification of this method has been devised and is at present under investigation, which eliminates the necessity of centrifugation. The container is made in two parts, but with essentially the same relative volumes and connected by a rubber stopper. The blood is taken under negative pressure and the container fire-sealed as previously described. The cells are then allowed to settle out into the lower chamber, and the upper chamber containing the plasma removed from the stopper and fire-sealed, forming an ampule as before. This latter method will be further detailed in subsequent publication.

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PLASMA THERAPY OF BURNS

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IT IS WELL-ESTABLISHED, on the basis of animal experimentation and clinical study, that severe burns cause a loss of plasma from the blood stream which is important. In this country, plasma has been used therapeutically in a number of clinics, and reports from abroad indicate that such therapy is being used extensively in war burns. It has not been generally appreciated that large amounts of plasma are indicated. This report presents the results obtained in two severe burn cases, with utilization of the formula of Elkinton, Wolff and Lee (ANNALS OF SURGERY, 112, 150, 1940) to estimate the amount of plasma which should be given to correct the deficit. This formula is as follows:

Plasma protein deficit in grams =

$$3.5\ W - \frac{W\ (100\text{-}Ho)\ HnPo}{2(100\text{-}Hn)Ho}$$

where W is the weight in kilograms, Ho is the observed hematocrit reading, Hn is the normal hematocrit (44), and Po is the observed plasma protein concentration. To convert grams of plasma protein to cubic centimeters of plasma, one multiplies by the factor 14.

The first patient had burns of the legs involving 20 per cent of the body surface. The initial hematocrit reading was 59.5, the initial plasma protein concentration was 6.68 Gm. per cent, and the weight of the patient was 80 Kg. When these figures were substituted in the formula, it was found that there was a plasma deficit of 1,876 cc. The patient was given 2,000 cc. of plasma over a 12-hour period. The next day, the hematocrit reading was 45 and the plasma protein concentration 6.49 Gm. per cent. No further plasma deficit developed.

The second case was more severely burned, with 45 per cent of the body surface being involved in third degree burns. The plasma deficit was calculated repeatedly during the first two days, and a total of 2,200 cc. of plasma was given. On the fourth day, the hematocrit reading was 40 and the plasma protein concentration was 5.9 Gm. per cent, indicating that the hemoconcentration was controlled by the plasma given during the first two days. In addition to the large amount of plasma, the patient also received 2 cc. of Cortate (desoxycorticosterone acetate, Schering) every four hours for five days.

Plasma therapy has been greatly facilitated by the establishment of blood banks and the use of rapid methods for the determination of plasma proteins from specific gravity determinations, either by the gravimetric or falling-drop methods.

A CRITICAL EVALUATION OF THE TREATMENT OF BURNS

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MUCH OF THE CONFUSION that exists in the literature of burn treatment results from failure to discriminate between treatment of the primary effects of the burn; treatment of the infected wound; and treatment of the granulating wound which has resulted from the destruction of skin. In any attempt to evaluate the primary treatment of the burn, we should fix attention upon the measures which affect the survival of the patient, regardless of their influence upon infection or epidermal growth.

Necropsies performed upon burned patients show few constant changes: chiefly, central necrosis of the liver lobules, passive congestion of all the viscera, and edema of the renal tubules. Occasionally, but not constantly, hemorrhage or necrosis of the suprarenal cortex is found, and occasionally ulceration of the mucosa of the gastro-intestinal tract.

There is ample clinical and experimental proof that during the hours following the burn there is increased permeability of the capillaries near the site of the burn (and possibly elsewhere in the body), with rapid loss of fluid from the circulating blood and deposit of fluid resembling blood plasma in the tissues near the burn, and in the blister fluid over the damaged epidermis. There is also fairly good evidence that at the same stage there is concentration of sodium ion in the burned tissue with resulting concentration of potassium in the blood. During this phase, blood concentration takes place and renal output is impaired, total blood protein and chlorides are reduced, and nitrogenous products increased.

Experimentally, the plasma shift seems to reach its maximum within a few hours, but, clinically, maximum blood concentration is not reached until the second or in rare instances the third day. It is not clear from present knowledge whether death is due to the physical phenomena alone or whether there is another "h-factor" or histamine-like substance produced at the site of the burn which causes widespread damage, of which the plasma shift is only one manifestation. Until this question can be answered primary burn treatment must be directed toward minimizing the known effects.

Early precipitation of protein at the site of the burn seems to definitely minimize the plasma shift and blood concentration and hasten the process of stabilization. Delayed coagulation seems to prolong blood concentration, placing an additional burden upon the heart and further impairing renal output, and increasing danger of later thrombotic complications. It seems quite possible that the prolonged anoxia suffered by the patient during the period of blood concentration may be the cause of the visceral changes mentioned, as suggested by McClure,[11] and may actually be the determining factor in the survival of the patient.

If we accept this premise, we immediately rule out as effective methods of treatment the use of continuous baths, oils, or ointments. We are, furthermore, unable to find any statistical evidence favoring these methods. Admitting at once the fallibility of statistics, especially in such lesions as burns, we believe they must be given some weight. In Chart 1 we see a continuous record by years of mortality on the Burn Service at St. Luke's Hospital, Cleveland. It is interesting to note that similar curves and mortality rates have been reported by Penberthy,[9] of Detroit, and Beekman,[13] of New York. Table I shows comparative figures from several representative clinics.

In a similar series, Allen,[10] of Chicago, makes a preliminary report of a mortality rate as low as ours, with a very different type of management, making use of débridement, meticulous cleansing, and encasing the burn in a snug gauze dressing. It seems likely that this method makes use of the serum coagulum on the surface of the burn and the pressure of the dressing to form an impervious covering for the burn and to minimize plasma shift.

Again, if our major premise be correct, rapid coagulation is also important because it affects the physical phenomena we have described. Of the various methods of coagulation which have been described (tannic acid, silver nitrate, gentian violet, ferric chloride, and combinations of aniline dyes), we believe that a combination of tannic acid and silver nitrate is by far the quickest and most effective. It is here also that prompt and effective first-aid treatment of the burn and well-organized hospital routine may be significant items.

In previous communications[12] we have considered in detail the management of the later stage of the burn, when the coagulum begins to separate. We will not consider further that part of the treatment here, other than to reiterate the fact that only with careful management (which in our experience means continuous Dakin's solution dressings) will later septic and thrombotic complications be avoided.

Two other adjuvants to the early treatment of the burn offer great possibilities, *i.e.*, the use of suprarenal cortical extract and the intravenous administration of blood plasma. The effect of these two additions to our armamentarium upon the severe burns during the past two years is problematic. We have had only a limited amount of blood plasma available, and have not been able to use it in quantities needed in accordance with the formulae developed by Elkinton, Wolff, and Lee.[14] There is suggestive evidence, nevertheless, that while large amounts of plasma are ideal from the standpoint of replacement, frequent doses of suprarenal cortical extract or its synthetic analogue desoxycorticosterone-acetate may, to a limited degree, along mith parenteral fluid take the place of plasma. Clinical experience has certainly shown that the individual has ability to compensate for degrees of plasma loss of considerable degree, without the use of plasma at all or with only limited quantities administered.

TABLE I

COMPARATIVE MORTALITY AT OTHER CLINICS

Author	Other Methods		Coagulation Regimen	
	No. Pts.	Mortal.	No. Pts.	Mortal.
Bancroft and Rogers, N. Y.[1]	90	40.0%	114	20.0%
Beekman, New York[2, 13]	320	37.8%	632	8.5%
Wilson, Edinburgh[3]	300	38.7%	117	11.1%
Harris, Toronto[4]		26.6%		12.0%
Mason, Philadelphia[5]	91	28.5%	87	13.3%
Langer, Vienna[6]	86	16.3%	65	7.7%
Mitchiner, London[7]	243	9.4%	249	2.4%
McClure and Allen, Detroit[8]	118	9.3%	358	11.7%
Glover, Cleveland	121	14.0%	894	7.8%
Total patients	1,369		2,516	
Average mortality		24.5%		9.2%

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DISCUSSION.—DR. HENRY N. HARKINS (Detroit): In the recent British literature,

during the past six months, especially since the evacuation of Dunkirk. I know of 15 men who have written concerning whether or not tannic acid treatment should be used on the hands and face. About half of these authors have said "yes" and about half have said "no." There is quite an argument going on in the editorials, especially in the British Medical Journal. I should like to ask Doctor Glover his opinion on this point.

DOCTOR GLOVER: We use tannic acid on the face. We have done so right along, ordinarily using the water-soluble tannic acid jelly, rather than the spray, for the reason that it is less likely to injure the eyes. If it is properly and carefully applied, the tannic acid in solution and silver nitrate in solution can also be used on the face, and it has been so used in some instances.

We have not used an anesthetic in any of the case in this entire series. We feel that anesthesia is contraindicated since it may add to the factor of shock, which is already present. We feel the cleaning-up process should be accomplished as gently as possible, so as not to add to the shock, which is already present. Usually, one dose of morphine was all that was required.

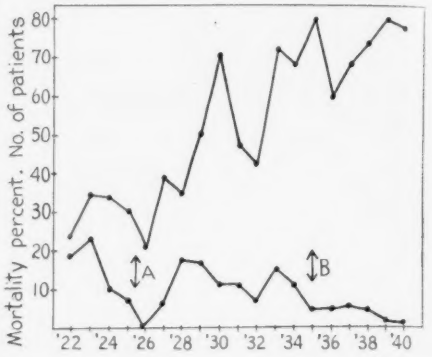

CHART 1.—Graphic representation of a continuous record, by years, of the mortality on the Burn Service at St. Luke's Hospital, Cleveland, Ohio.

DEFORMITIES DUE TO BURNS

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IT IS common knowledge that third degree burns may cause serious deformity or hideous disfigurement. By definition, third degree burns are those which destroy the entire thickness of the skin and more or less underlying tissue. Such wounds heal slowly by granulation, cicatrization, and ingrowth of epithelium from the edges. In general, therefore, the deformity will depend chiefly upon the location and the extent of tissue destruction. It is obvious, however, that the end-result of such a healing process may be greatly improved by proper surgical treatment.

I wish especially to emphasize the fact that all large areas of granulation tissue should be skin grafted as early as possible. Without this procedure, healing will be greatly delayed and the deformity will be unnecessarily increased. In many instances, complete and satisfactory healing is impossible without the aid of skin grafts or other plastic surgical procedures. This is especially true of deep burns involving the face, the neck, the axillae, and the extremities. The following two cases are cited as examples:

CASE 1.—A woman, age 48, suffered a third degree burn of her neck, the lower part of her face, and the upper part of her chest, October, 1938.

Six months later, when I first saw her, the burn was incompletely healed with a severe scar contracture as shown in Figure 1A. Residual granulating areas on the upper chest were infected and the healing process was evidently at a standstill. These wounds were treated with continuous wet dressings of 0.5 per cent chloramine solution, with daily application of 5 per cent mercurochrome to the granulation tissue for approximately three weeks.

At this time, the neck contracture was relieved by radical excision of the scar contracture under general anesthesia. The

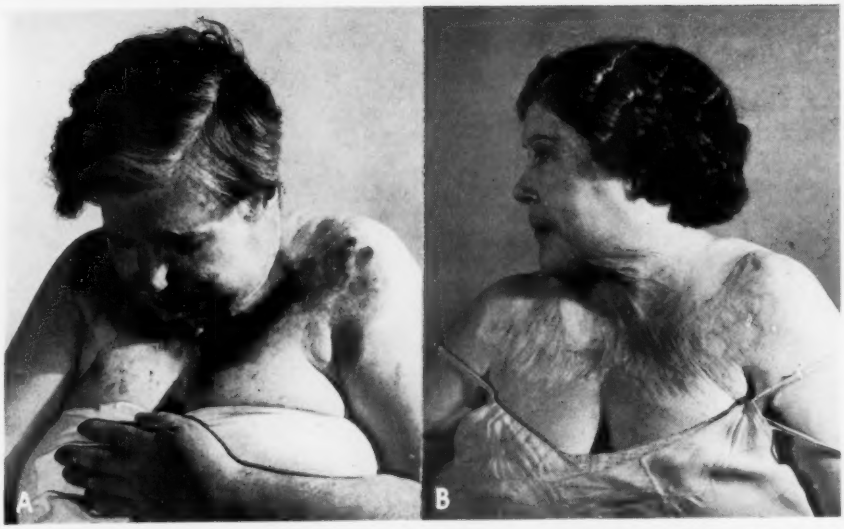

FIG. 1.—(A) Showing incompletely healed burn and severe scar contracture. (B) Result one year after the initial graft.

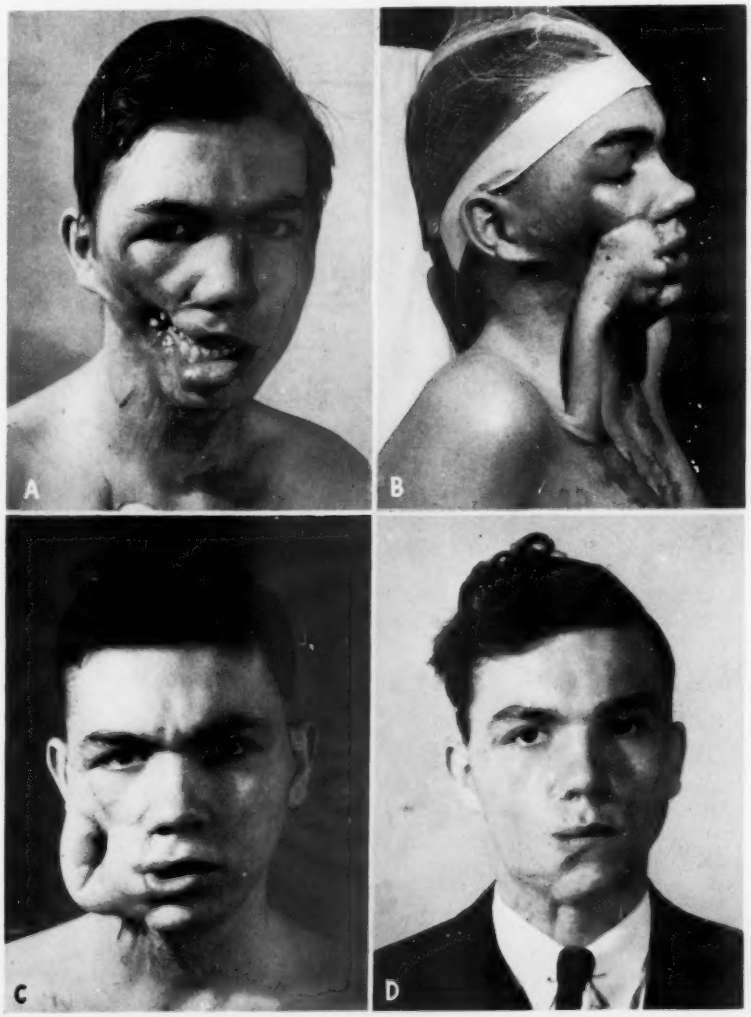

FIG. 2.—(A, B, C, D) Showing serial stages of repair during a period covering two years.

large raw surface involving the entire anterior aspect of the neck was covered with four large split-skin grafts which were removed from the thigh and sutured into the neck wound. The grafted area was covered with a pressure dressing kept moist continuously with 0.5 per cent chloramine solution.

These grafts "took" completely but several smaller grafts were necessary later to produce complete healing of the chest wounds. Figure 1B shows the result one year after the initial graft. Further improvement could be accomplished by additional split-skin graft.

CASE 2.—A boy, age 14, suffered a deep burn of the right side of his face, September, 1937. The accident occurred when he became asphyxiated and fell unconscious with his face against a hot water heater in the bathroom of his home.

The resultant burn destroyed the right side of his face as shown in Figure 2A. This photograph was taken approximately four months after the burn, and shows a defect which can be repaired only by means of a large pedunculated flap. In this instance it seemed advisable to use a rolled pedunculated flap. The lower end of the flap was lined with a full-thickness skin graft to give an inner surface to the reconstructed cheek. The photographs in Figure 2 show various stages in the manipulation and utilization of the rolled flap. Ten operations were required. Figure 2D shows the result two years after the injury. Further improvement could be obtained but the patient, at the present time, is satisfied with the result.

THE TREATMENT OF COMPLETE DISLOCATION OF THE OUTER END OF THE CLAVICLE

An Hitherto Undescribed Operation

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AS IS WELL-KNOWN by all surgeons, displacements at the acromioclavicular joint are more frequently incomplete; to this type of injury the term subluxation is usually applied. It is generally recognized that such injuries usually repair without disability if adequate fixation of the two bones in proper position is maintained for a suitable length of time. It is not my intention in this contribution to refer to this type of lesion.

Less commonly there is a complete dissociation of the lateral end of the clavicle and the acromion. In such cases, the end of the clavicle overrides the acromion and complete rupture of all the ligaments taking part in the acromioclavicular joint occurs. The statement has been so frequently made, that in addition to rupture of the acromioclavicular ligaments in such a lesion rupture of the coracoclavicular ligament also occurs in these cases, that the accuracy of this statement has been very generally accepted. My own experience indicates that this is not so.

Practically all text-books on anatomy and on surgery, including those specifically dealing with fractures, make the statement that it is the function of the clavicle to support the scapula and to act as a strut which fixes the shoulder at the proper distance from the sternum. Although when the clavicle is fractured in the usual position at about the junction of the middle and outer third, the outer end of the proximal fragment has a tendency to become elevated and the shoulder and outer fragment of the clavicle to drop, and although there is usually present more or less overriding of the fragments, it would appear that these deformities are the result rather of the original injury than due to loss of continuity of the bone.

The clavicle does not act as a strut nor does it support the shoulder. That these statements are true is proven, I believe, by the fact that complete removal of the clavicle is not followed by either shortening of the distance from the tip of the shoulder to the midline of the body nor by dropping of the shoulder on the affected side. The major function of the clavicle is to act as an attachment or a *point d'appui* for the muscles attached to it, more especially the pec-

toralis major, the deltoid, the sternocleidomastoid, and the trapezius. It would appear evident that the proper position of the shoulder is dependent upon adequate functioning of these muscles and not upon the mechanical support given by the bone.

The fact that the clavicle is practically functionless in the human being was first drawn to my attention when, in 1912, the left clavicle was completely resected, together with its periosteum and with the muscles immediately attached to it, on account of small round cell sarcoma in a child, age 14. Although the patient died four years later of metastases, recurrences in different parts of the body having been controlled in the meantime by radiation therapy, the fact that no shoulder deformity nor loss of function occurred, impressed me greatly. In this case, following removal of the clavicle, the muscles which had been attached to it were securely united to one another so that each acted as a point of fixation for the other. In January, 1927, the following case was operated upon:

Case 1.—L. L., age 30. While in the Russian Army, 1916, machine-gun bullet wound of the right elbow. Three months' leave, no treatment. Return to full duty in the army and afterward worked as a common laborer. Prior to admission he was working as a pedlar, pulling a sleigh. He felt something crack in the left clavicle. Examination showed him to be suffering from a pathologic fracture about the middle of the clavicle. He was operated upon and a complete resection was performed of the left clavicle together with periosteum and approximately 2 cm. of muscles attached on all borders. The divided muscles were carefully sewn to one another. A diagnosis of round cell sarcoma was made.

He returned to work about two months after operation, and has continued at work more or less continuously since that time. Six months after the operation upon his shoulder, he was again operated upon and a machine-gun bullet removed from the right elbow on account of pain and loss of function of that joint.

This man has remained well. At the present time he is engaged as a shipper in a wholesale vegetable establishment, in consequence of which from morning to night during a long day he is continuously handling heavy packages up to 150 pounds in weight. Although he suffers a substantial disability referable to the right elbow joint region he is emphatic in his statement that there is no disability referable to the left shoulder. The accompanying photographs prove, on the one hand, that the left clavicle is completely missing and, also, that there is no deformity nor limitation of movement.

Top.—FIG. 1. Case 1: Roentgenogram, January, 1940, 13 years after complete resection of left clavicle. Note scapula in normal position.

Middle and bottom.—FIG. 2: Case 1: Photographs, January, 1940. Note scar at site of removal of left clavicle; absence of deformity of shoulder; and presence of full range of movement in all directions of left shoulder joint.

In December, 1939, a man presented himself with complete clinical dislocation of the outer end of the clavicle:

Case 2.—Hospital No. 7634-39: A. A., age 26. This patient was first seen December 13, 1939. He gave the history

that he had been injured, November 1, 1939, while boxing. Examination showed a complete dislocation of the lateral end of the right clavicle, with overriding of approximately 2 cm. of this bone on to the superficial surface of the acromion. Correction of the deformity could not be carried out.

Based upon a conviction that the clavicle is in fact one of the spare parts of the human anatomy, it was decided to resect the lateral third of this bone. A curved incision below the distal half of the clavicle and extending to the tip of the acromion, so placed that it would lie beneath the line of the clavicle and be away from pressure points, was employed. This incision was carried down through the skin and subcutaneous tissue to the fascia covering the muscle, and the flap thus made turned upward. A small incision was made through the medial portion of the deltoid muscle in order that the coracoid process might be examined and the integrity of the coracoclavicular ligament established. It was found to be impossible to pass a finger between the coracoid and the clavicle. It seemed evident, therefore, that the ligament was intact.

The periosteum was removed from approximately the distal third of the clavicle and, with the finger in the wound pressed against the coracoclavicular ligament, that portion of the clavicle distal to this point was resected. For this purpose Bethune's rib-cutting shears were employed; two bites being necessary to divide the bone. There was no evidence whatever of any ligamentous structure in the neighborhood of the acromioclavicular joint nor was there any evidence of a joint surface on either clavicle or acromion.

The wound was carefully closed in layers—No. 0 chromic catgut for the deeper structures and No. 00 plain catgut for the subcutaneous tissues; clips were employed to close the skin. Care was taken to so place the deep sutures that the periosteal tube was obliterated and the muscles attached to the anterior and posterior borders approximated.

A small dressing was applied and the patient returned to bed, the wrist being tied to the head of the bed and the latter elevated six inches. This position was comfortable, and was maintained for five days, at which time the clips were removed and the arm gradually brought to the side by the patient.

December 26, the eighth postoperative

Top.—FIG. 3: Case 2: Photographs prior to operation. The overriding of the outer end of the clavicle on top of the acromion is clearly illustrated.

Bottom left.—FIG. 4: Case 2: Roentgenogram of shoulder showing overriding of clavicle on top of acromion process.

Bottom right.—FIG. 5: Case 2: Postoperative roentgenogram showing resection of outer end of clavicle. Note absence of displacement of scapula.

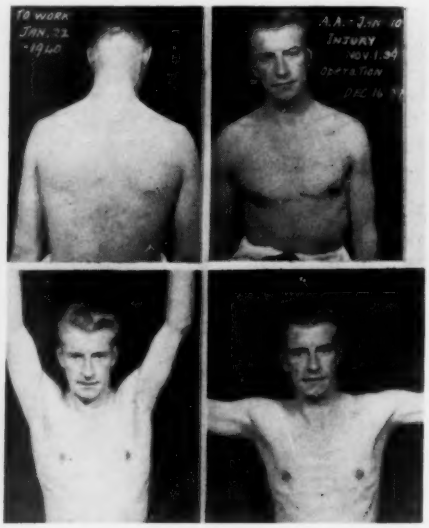

FIG. 6: Case 2: Photographs illustrating complete movement in all directions, without deformity of right shoulder joint.

day, the patient was allowed out of bed with the arm in a sling. He was discharged from the hospital January 2, 1940, and returned to work February 1, 1940.

As this young man is employed as the operator of a steam shovel, which is a two-handed job, requiring very considerable strength in both upper extremities, and since he has been able to continue with his work, it is evident that he suffers no disability due to the loss of a portion of the clavicle. The importance of his disability and the fact that other forms of treatment would be, on the one hand, more hazardous and, on the other, more complicated, induced me in this case to put my opinions with regard to the clavicle to the test.

FIG. 7.

FIG. 8.

FIG. 7.—Case 3: Preoperative roentgenogram showing overriding of outer end of clavicle above acromion.

FIG. 8.—Case 3: Postoperative roentgenogram showing resection of lateral end of clavicle, without deformity of scapula.

Not long after my satisfactory experience with Case 2, the following patient was admitted to my service:

Case 3.—Hospital No. 1732-40: H. B., male, age 29, fell, March 20, 1940, a distance of ten feet from a ladder landing on the tip of the left shoulder. On examination, a complete dislocation of the outer end of the clavicle on the acromion was noted.

Five days following injury, March 25, 1940, under cyclopropane anesthesia an operation similar to that described for Case 2 was carried out. Again the integrity of the coracoclavicular ligament was established and this structure used as a marker for removal of the outer end of the clavicle. As in Case 1, no remains of ligamentous tissue about the acromioclavicular joint, which might have been used in an attempted repair of this joint, could be identified.

The patient was returned to bed, again, with the wrist tied to the top of the bed and the latter raised. Clips were removed May 30, and the arm allowed to be brought to the side. On the eleventh postoperative day, April 5, he was out of bed and was discharged from hospital three days later.

He returned to work, May 1, as mechanic in a locomotive works. He has since been accepted for service in the C.A.S.F., and is, consequently, not available for further check-up.

Operation in the two cases reported was carried out in exactly the same way in both. A curved incision, convexity downward, was made just below the outer half of the clavicle, through skin and subcutaneous tissue. The flap so fashioned was turned upward so as to expose the outer third of the clavicle. The periosteum was removed from the clavicle so that approximately the outer third of the bone was bared. At this stage, the left index finger was inserted beneath the clavicle and pressed medially against the coracoclavicular ligament, which was evidently intact. Using the index finger as a guide, the clavicle was cut off at this point, for this purpose Bethune's rib shears were employed. The periosteal bed, together with the muscles attached to it, was then carefully closed, using for the first case No. 0 chromic sutures and for the second, fine black silk. The flap was replaced with a subcutaneous suture and clips to the skin.

The wrist was tied to the head of the bed and the latter raised a distance of about six inches. This position was maintained for five days when the clips were removed and the patient allowed up three days later.

As compared with the more radical method of attempting to repair the disorganized joint, particularly in long-standing cases, by the method of fascial suturing of the clavicle to the coracoid and the acromion to the clavicle, the method described, and recommended, is one which, on the one hand, is much less time-consuming at operation and, consequently, less likely to be followed by infection; and on the other hand, since the period which need elapse before return of function is attempted is only dependent upon the time required for soft tissue healing, the period of invalidism is substantially shortened.

SUMMARY

Proof has been offered that the general opinion as to the function of the clavicle is wrong. It would appear that the clavicle is of importance only for cosmetic reasons and to serve as a *point d'appui* for muscle action.

A simple operative procedure is recommended for complete dislocation of the lateral end of the clavicle for both early and late cases. The period of hospitalization and the time required before return of full physical activity are considerably shorter than when more intricate procedures are employed. Physiotherapy is not required.

The number of cases reported is admittedly small but they are, I believe, sufficiently important to justify the recommendations made.

PROGRESS IN THE MANAGEMENT OF SEVERE SUPRACONDYLAR FRACTURES OF THE ELBOW

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DURING THE COURSE of the past two decades or so, our ideas of the care of these severe supracondylar fractures have progressively changed. In the early years we, like most other surgeons, were accustomed to attempt reduction by manipulation under anesthesia, and followed this by immobilization of the arm in plaster. We found, however, that, too often, the trauma incident to these maneuvers added much insult to the already severely damaged soft tissues and, too often, also failed to accomplish satisfactory reduction even after repeated attempts, with consequent impairment of function and frequently marked gross deformity at the elbow.

About two years ago, there was admitted a boy having great damage to the soft tissues in the region of his elbow, associated with a supracondylar fracture, with extensive blistering of the skin, obstruction of his radial pulse, and complete paralysis of the median nerve. None of the methods of treatment with which we were familiar could be employed, and we were much concerned about saving his arm. This situation prompted us to devise a different method of procedure, one which could under all circumstances accomplish accurate reduction without adding injury to the soft tissues, avoid the necessity of an open operation, and perhaps even eliminate a general anesthesia. We agreed that such a method should involve an apparatus which was very simple and inexpensive. It should be applicable in a few minutes' time to any style of hospital bed, and should allow, easily, for necessary changes in the position of the bony fragments. We were about that time greatly impressed with the work of Dunlop, of Pasadena, on this same problem and, also, were cognizant of the success of a simple method of skeletal traction by means of a screw in the ulna which had been employed for several years in adults by Doctors Cubbins, Callahan, and Scuderi of the Cook County Hospital, of Chicago.

In principle, this method (which we have routinely employed on all severe supracondylar fractures in our ward at the County Hospital since January, 1939) does away with the old ambulatory treatment, and substitutes in its place slow reduction by traction and suspension with the patient in bed for a period of about three weeks. In detail, the procedure is as follows: On

admission, the extremity is carefully examined to determine the adequacy of the circulation or evidence of nerve injury. Anteroposterior and lateral roentgenograms are taken to determine the amount and type of displacement. Ordinarily, as most surgeons well know, the short lower fragment is displaced backward, rotated inward, and too often is displaced laterally or medially. Depending on the length of time since the injury, there is a variable amount of swelling, induration, and discoloration about the elbow. Very often, too, there is severe blistering, and sometimes the sharp lower edge of the upper fragment injures the median nerve and may even pierce the skin.

Morphine is administered, and one-half hour later, when the child is cooperative, the area about the elbow is carefully cleansed

FIG. 1.—Traction suspension with screw in the ulna. Method employed in about two-thirds of cases in this series.

with soap and water, 1 per cent novocain is infiltrated, and an incision about 1 cm. in length is made approximately an inch distal to the olecranon over the flat surface of the ulna. Using an ordinary Yankee drill, holding a 3/16-inch drill point, a hole is made deep enough to allow a size No. 10 eyelet screw to be turned securely into the bone.

The child is placed in a crib bed on the side of which is fastened a Thomas splint widely spread at its base. The injured arm is gently drawn between the padded upright bars of the crib side, the hand being held steady with the elbow at about a right angle, as the traction cord is attached to the screw in the ulna, and to which is added a weight of approximately five pounds. This at once establishes direct traction and countertraction on the short distal fragment. Upward pull on the distal fragment is then established by adhesive traction vertically on the forearm while downward pull on the proximal fragment is established through a well-padded moleskin sling to which approximately a three pound weight is attached.

This combination effectively produces traction in four directions at the same time and, in most instances, very rapidly produces satisfactory reduction of the fracture. If the subsequent roentgenograms, which are very easily taken, show incomplete alignment, changes can be made in the direction or amount of pull on either the distal or proximal fragments. It is frequently necessary to make repeated changes over a period of a few days before the alignment is considered satisfactory and, as a criterion of satisfaction, we aim to clearly visualize the olecranon fossa in the anteroposterior film and a perfect alignment as seen in the lateral film.

As a rule, the patient is kept in traction for 18 to 21 days, at which time there is sufficient callus formed to preserve the position. The screw is then removed without anesthesia and a posterior plaster mold applied. About four weeks after the injury, all immobilization is discarded and active motion encouraged. In about a third of the patients in this series, namely those in which the degree of displacement was less severe, we have eliminated the use of the screw and have been satisfied simply with adhesive traction on the forearm, as practiced by Dunlop.

Results.—During this period since January 24, 1939, we have cared for 82 cases by the method here described. In the 74 cases which were observed long enough to reasonably establish the accuracy of the end-results, the outcome was uniformly good except in two cases, as measured in terms of complete flexion and extension, unrestricted rotation, normal carrying angle, and absence of nerve impairment. These results seem to us remarkable in view of the

fact that five of these injuries were compound, 12 of them had concomitant nerve injury (all of which cleared spontaneously within three months), and eight had impairment or obliteration of the radial pulse. In the two cases which, according to our criteria, were not classed as good results, both had flexion limited to 90°, and one had extension limited to 150°.

CONCLUSIONS

We wish to make it clear that in these severe supracondylar fractures of the humerus the ambulatory treatment with attempted reduction by manipulation (too often repeated), and followed by immobilization in plaster, has, in our hands, given way to the traction-suspension method which we have here described. The reasons for this are as follows:

(1) The apparatus used is simple and very inexpensive.

(2) This method accomplishes accuracy of reduction without adding injury to the soft tissues, and thus minimizes the likelihood of vascular and nerve complications.

(3) It readily allows for changes to be made as indicated by subsequent roentgenograms.

(4) It practically abolishes the need for open operations (none in this series have required it).

(5) The most important consideration of all is the fact that it produces end-results which are almost uniformly satisfactory.

The only disadvantage of this method is the necessity for hospitalization of the patient for a period of three weeks. We feel, however, that this disadvantage is far outweighed by the advantages gained.

AMPUTATIONS THROUGH FINGERS

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AMPUTATIONS through fingers are the most unsatisfactory amputations that surgeons perform. More patients return demanding reamputation than in any other part of the body. The reasons for the disappointing end-results are several:

(1) *Short Flaps.*—These are probably the most common cause of painful results. Flaps in fingers should be twice as long as flaps in thigh amputations—relative to the size of the part. That is to say, the total of the two flaps in a finger should equal twice the diameter of finger. This is necessary because such a large proportion of the finger is occupied by hard, unyielding bone, and fibrous tissue, while in the leg the bone is relatively much less. Skin flaps always shrink.

(2) *Neuromata.*—Often painful nerve bulbs develop on the end of the cut digital nerves. Such bulbs are close under the skin or even in the scar, and are exquisitely painful on pressure. They may set the stage for causalgia.

Obviously, then, at the time of operation, it is always desirable to locate the digital nerves, to draw them down, and cut them off short, allowing the end to retract far away from the scar.

(3) *Stiff Joints.*—The old principle, "save all you can—it may live," is wrong, because it thinks in terms of anatomy rather than physiology. There is no point in saving fingers so badly smashed that they can never be useful. Many a patient comes back, after a year of useless suffering, to have a stiff, distorted finger removed. If it had been removed primarily, he would have been back to work in a few weeks. Save function rather than form.

In general, go high enough so that the amputation is through vital tissue, hence prompt healing and early movement. A crushing of two bones, with a shattered joint between, calls for removal. Joints so badly disorganized, as to become stiff, are no good. Shredded or missing tendons render a finger useless. If pus is present, never amputate through bone—disarticulate if necessary.

(4) *Wrong Level.*—In the leg, definite levels are recognized as giving best results. All are familiar with the advantages and disadvantages of a Syme's, a "below-knee," and a Gritti-Stokes. In the upper extremity, and particularly in the hand, no such clear concept has been offered. Yet the many who return asking the removal of stumps, which are worse than useless, and which invite further injury, suggest that

some amputations are more satisfactory than others.

Since the thumb is the most important member of the hand, the rule is to save as much of its length as possible. If it is to be stiff, see that it is well toward the front, over the palm, where the fingers can reach it. A stiff thumb, lying alongside the fingers, is a serious disability.

In accidental amputation, through any distal phalanx, to restore function in minimum time, remove sufficient bone to permit sewing the anterior and posterior skin edges together. If appearance is of more concern, further loss of length can be avoided by suturing to the flat end of the stump a small, fairly thick Thiersch graft from upper forearm or abdomen. Loss of a distal phalanx is considered no handicap to earning. The Compensation Board and many insurance companies give no disability allowance.

If injury to the left index finger forces amputation any higher than the proximal joint, one should immediately amputate well proximal to the head of the metacarpal, because a short left index stump is useless and likely to be hit at work. The metacarpal should be beveled so that no useless hump remains between middle finger and thumb to cause months of inefficient work and culminating in reamputation. A short right index stump may at times be permitted as a guide in handling tools, even though it adds little to the grip.

Save as much of the middle and ring fingers as possible. These stumps lend strength to the grasp and keep the index finger in line. Disarticulation at the knuckle joint is not a good operation. The head, together with a moderate portion of shaft of a metacarpal, should be removed.

Amputation of part or all of the little finger should constitute no disability and may, therefore, be carried out at any level where it is easy to obtain good flaps. Disarticulation at the knuckle is to be avoided and should be replaced by a beveled amputation halfway down the shaft of the metacarpal.

WRINGER INJURIES OF THE UPPER EXTREMITY

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ANYONE who sees a large number of injured hands and arms, as at a charity institution, will encounter a certain group of cases which have been called "wringer injuries." These injuries are the result of the hand, forearm, or arm, being drawn between the rollers of the washing machine wringer. The rollers may produce crushing of the soft tissues or, in those cases where the extremity is forcibly withdrawn against the rollers, there may occur a tearing of the soft tissues leaving an open wound. Whether the skin is, or is not divided there may occur later a necrosis and loss of the superficial soft tissues as a result of the crushing.

MacCollum,[1] in 1938, first described this entity and reported 26 cases. In the early cases, he advised measures to reduce the edema of the arm by the use of a sling for elevation and ice packs, later changing to alternate hot and cold packs. For the late cases, that is after necrosis and usually infection had appeared, he advised measures to aid in separating the nonviable soft tissue, usually saline or boric acid soaks.

At the Hand Clinic and the Children's Ward, we have seen 107 cases of wringer injuries during the past two years. The pathology has consisted of a crushing or tearing injury, and has been confined mainly to the skin and subcutaneous tissues. The sites for the injury to occur are at points of enlargement of the extremity as the bony prominence at the elbow, muscle bellies of the proximal forearm, the wrist, or at the level of the metacarpophalangeal joint in the hand. In a few children, the rollers have progressed up the arm to the axilla where they have con-

tinued to turn, and have torn away a large flap on the under surface of the upper arm, extending onto the chest wall and back.

The tearing may result from some obstruction to the rollers or to forceful extraction of the part. The laceration is confined to the skin and subcutaneous fat and fascia down to the deep fascia of the arm. This produces a thick flap with a distally attached pedicle, which may be of varying size. The skin edges are torn in a ragged manner, but there is little bleeding. In most injuries, there is only a crushing of the part giving to it early some ecchymosis and swelling, probably due to injured superficial vessels. This swelling progresses and may become very extensive. At the most seriously crushed areas, the skin will gradually become gangrenous and slough away leaving an open wound, and infection may be superimposed, thus leading to a further loss of tissue.

In these cases of wringer injuries, we have never seen muscles torn, but there may often be an infiltration of the muscle as a result of the bleeding and edema, and this may result in delayed return of function. In this series, there has been no nerve or tendon injuries. Two fractures have occurred, one a "greenstick" of the ulna, the other a fracture of a terminal phalanx, with no displacement. Neither fracture influenced the treatment.

The treatment of the cases with lacerations has been immediate surgical cleansing and closure of the defect. Under a general anesthesia, the surrounding skin is cleansed for ten minutes with soap and water, and then the wound itself is gently cleansed and flushed. The edges of the skin are examined and the proximal edge of the flap is débrided until viable-appearing skin and soft tissue are reached. Often this débridement may make it impossible to close the wound; however, it is necessary to cut away the edges to viable, bleeding tissue. If it is impossible to close the wound, a free skin graft of intermediate thickness may be placed over the defect. The wound must be closed. Over the site of the laceration, or graft, and well beyond it, the arm is covered with a large sterile dressing of fluffed gauze, and often sea sponges. This dressing is then bandaged snugly to give a sustained resilient pressure-dressing. A splint is applied to the outside of the dressing. The dressings are changed after six to ten days have elapsed.

The pressure-dressing is applied to keep the subcutaneous tissues or graft held firmly in place and to diminish the amount of subsequent edema that will occur. The edema may itself cause further loss of skin by separating the skin from its source of blood supply. The uncontrolled swelling may cause obstruction to the vessels of the skin pedicle, producing gangrene of the flap.

In cases where the arm or hand has only been crushed, it is important to remember that necrosis may occur alter. Too often, the patients have stated that they sought immediate care, but that only a roentgenogram of the part was taken, and the patient then dismissed. Within 12 to 48 hours, the hand or arm has become swollen, tense, ecchymotic, and this area has progressed on to necrosis of the skin, often of large size, as the entire back of the hand. The cases with swelling only, and no laceration, have seemed to take a longer time to obtain good functional return—possibly due to muscle infiltration of blood and serum.

If the hand or forearm is only crushed, it is best to cleanse the part carefully and apply a pressure-dressing and a splint, so as to diminish the amounts of subsequent edema and of possible skin loss. The pressure-dressing can be left in place for five to seven days and then the part inspected for signs of necrosis of skin. If none is present, the dressings may be discontinued; if necrosis is present, the pressure-dressings and splint are continued until the part is healed or the gangrenous skin has separated, and the area is ready to receive a skin graft.

SUMMARY.—Wringer injuries produce a crushing and often tearing laceration at certain sites on the upper extremity.

The open wounds must be cleansed and closed. The resulting pedicle of skin must be carefuly débrided until healthy viable skin is obtained. Often a skin graft is required.

The wringer injuries with crushing only, and no open laceration, may later result in necrosis of the skin. These cases when seen early must be cleansed, splinted, and covered with large pressure-dressings.

The value of pressure-dressings and splints has been emphasized to combat the late swelling which itself may produce loss of skin.

REFERENCE

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TUBERCULOSIS OF THE HIP

A Review of Seventy-six Cases with Proven Tuberculous Arthritis of Seventy-seven Hips Treated by Arthrodesis

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A REVIEW of 76 patients with tuberculous arthritis in 77 hip joints is presented. In each case the diagnosis was proven by pathologic or bacteriologic methods. In each case an arthrodesis was performed as part of the treatment. Both general and local therapy, designed to improve the general health and to furnish complete rest to the hip, is recommended for considerable periods both pre- and postoperatively. The authors feel that a permanent bony ankylosis affords the best chance of a permanent cure of the disease. The end-results were judged from a symptom-questionnaire obtained seven years and five months postoperatively, and from clinical and roentgenographic examinations carried out four years and five months postoperatively.

The end-results were good in 51 per cent, fair in 22 per cent, poor in 8 per cent, and the total mortality was 18 per cent. It was noteworthy that 72 per cent of the patients were rehabilitated and had good results from a symptomatic standpoint. However, the authors' reluctance to classify a fibrous ankylosis as better than a fair result accounted for the decrease in good results in the final judgment.

The study supports the contention that the arthrodesis should be performed at an optimum time in the course of the disease. The group of patients having the best results had over six months of preoperative treatment, which was prolonged until the general health was good, all other tuberculous foci were quiescent, and the hip tuberculosis was relatively quiescent. Better results were obtained in the group having the arthrodesis performed between the ages of eight and 18 years. The results were definitely inferior if the operation was performed in the presence of sinuses or cold abscesses about the hip. The seriousness of mixed tuberculous and pyogenic infection of the hip is indicated by the high incidence of this complication in the poor results and deaths. These conclusions conform, in general, with those of other observers.

TENDON IMPLANTATIONS TO BONE

A Study of the Factors Affecting Tendon-Bone Union as Determined by the Tensile Strength

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USING ASEPTIC TECHNIC, the tendon of the extensor carpi radialis longus muscle was divided distally and pulled through a drill-hole in the radius, bilaterally. Fifty-two dogs were operated upon, and divided into two groups because of variations in the procedure. In Group I, the tendon sheath was left intact and the relative size of the drill-hole varied so that the tendon fitted snugly on one side and loosely on the other. In the second group, the portion of the tendon implanted into the bony tunnel was stripped of its sheath, its component fibers separated, and bone-sand from the drill-hole interposed between the strands. One leg was immobilized in a plaster encasement. The animals were sacrificed at periods of one to 173 days, and the tensile strength of union between bone and tendon measured. These measurements were compared with the tensile strength of: (1) The mechanical fixation only; and (2) the normal extensor carpi radialis longus attachment to bone. The tensile strength of mechanical fixation alone varied from six to 13 pounds. The musculotendinous junction was found to be the weakest link in the chain in the normal animal, and separated with a pull of from 27 to 38 pounds.

The tensile strength curve for attachment

of bone to tendon was found to have the same general shape as that for other healing wounds. There is a lag-period, during which the tensile strength falls and is less than that of freshly anchored tendon: then it rises gradually during the period of fibroplasia, and in 21 days attains a tensile strength of six pounds. Normal physiologic strength was attained in Group I in 71 days, and, within limits, the relative size of the drill-hole had no effect upon the rate of union of tendon to bone. Shredding of the tendon, as in Group II, allows the surrounding fibroblasts a larger area for attachment, and normal physiologic strength was attained in 35 days. Immobilization in a plaster encasement for 21 days carries the mechanical fixation over the lag-period until physiologic fixation occurs. Prolonged immobilization retards the rate of rise of tensile strength.

From this, it is concluded that optimum results with tendon implantation to bone may be expected when: (1) The portion of the tendon implanted in the bony tunnel is stripped of its sheath and its component fibers separated; (2) the limb is immobilized in a plaster encasement for 21 days; and (3) active and passive motion are begun and gradually increased up to the thirty-fifth day, by which time normal physiologic strength of union will have been attained.

THE USE OF HORMONE THERAPY IN CRYPTORCHIDISM

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THE USE of gonadotropic hormone in treating cryptorchidism was first reported by Shapiro, in 1930. Since then the literature has been filled with series of cases treated with the gonadotropic hormone of pregnancy urine (A.P.L.) and more recently with reports concerning the use of the male sex hormone (testosterone). There is wide variance in the results obtained by different authors, with satisfactory results ranging from 10 to 80 per cent. The purpose of this discussion is to summarize the situation, and the present status of hormone therapy.

Cryptorchidism means incomplete descent of the testis. The condition may be unilateral or bilateral. The testis may be retained within the abdominal cavity or in the inguinal canal. Congenital hernia is associated with 75 per cent of cryptorchidism. A small but definite proportion of the cases shows evidence of pituitary deficiency, or associated genital abnormalities, such as hypospadias. These factors must all be considered in deciding between hormonal therapy and surgical correction.

There are two conditions simulating cryptorchidism which must be distinguished from it: Ectopy of the testis; and pseudocryptorchidism. Hormone therapy is not indicated in either, although both types of cases have been included in many reports. Ectopy of the testis, in which the testis leaves the normal path of descent after passing through the external inguinal ring, may follow one of these common sites of aberration: Outside the sheath of the external oblique muscle; between the external and internal inguinal rings; above the symphysis pubis; in the perineum; or in the thigh. It is obvious that hormone therapy will not cause the testis to retrace its steps, and then descend normally. Careful examination will reveal these conditions, which should be treated by surgical fixation of the testis. Pseudocryptorchidism must be ruled out. Frequently, in young children with active cremasteric reflexes, the fright or manipulation of an examination will cause retraction of the testes high into the scrotum or into the inguinal canal. These children are normal, and do not need hormone therapy. The condition can be distinguished by waiting until the child is relaxed, or having the mother examine him while asleep. Inclusion of these has given unusually optimistic results in some series of cases, since, sooner or later, they will be found in normal position at subsequent examinations.

If the patient is truly cryptorchid, however, a course of hormone therapy is indicated before surgical correction. Since it is desirable to have the testis in its normal scrotal position before puberty, it is well to give the course between the ages of six and 12, so that orchidopexy can be performed before puberty if hormone therapy fails.

Two preparations have been used. The first hormone used is the gonadotropic hormone found in the urine of pregnancy, known as A.P.L., and is sold under a variety of trade names. Its behavior, as far as the testis is concerned, is exactly like the luteinizing factor of the pituitary gonadotropic hormone (L.H.). Besides causing testicular descent in some cases, it also stimulates the interstitial cells of the testis to produce male sex hormone (M.S.H., testosterone) which, in turn, stimulates the accessory genital structures (prostate, seminal vesicles, penile growth) and secondary sex characteristics. The dosage of this hormone varies in different series, but the use of 300 M.U. three times weekly, is probably sufficiently generous. The course should extend for two months, allowing a total dosage of about 7,000 M.U. If descent has not occurred significantly at the end of this time, further therapy will probably be useless. Hormone therapy should be stopped regardless of the amount given if excessive genital growth or development of adult secondary sex characteristics occurs.

The other hormone which has been used is the male sex hormone—testosterone. Testicular descent does occur in some cases where it has been employed, and it is conceivable that the action of the A.P.L. is indirect, by stimulating production of testosterone by the testis. Not many statistics are available, but results of treatment with testosterone are roughly comparable to those with A.P.L. Objections to its use are its expense; and the fact that effective doses cause quite marked genital growth. The average dose used is about 10 mg. of testosterone propionate three times weekly for eight weeks.

Results of endocrine therapy in cryptorchidism have been extremely variable. Thompson and Heckel, in a review of the literature (1939), found a total of 860 undescended testes in 579 patients, with average successful results reported in 61 per cent; their own series of 50 undescended testes in 38 patients showed only 20 per cent successful results. In all cases, A.P.L. was used in adequate dosage. The discrepancy is still not entirely explained although the more recent, carefully studied series approximate Thompson and Heckel's results. Inclusion of pseudocryptorchids undoubtedly accounts for better results in some series.

If hormone therapy as outlined above is unsuccessful, orchidopexy should be completed before the age of puberty, so that normal development of germinal epithelium will take place and the likelihood of testicular tumor be decreased.

A FIRST STAGE OPERATIVE METHOD IN THE TREATMENT OF HYPOSPADIAS

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During the past three years at the University Hospital, we have employed a first stage operation for hypospadias developed by Reed M. Nesbit.

As the first step, an encircling incision is carried out directly behind the corona, and the skin and subcutaneous tissues are dissected free as far back as the abnormally located urethral meatus (Fig. 1). This exposes the band of scar tissue, which represents the fibrous and hypogenetic corpus spongiosum. Following the complete excision of this scar (Fig. 2) the penis can be easily straightened out, with a lengthening of the shaft and a backward displacement of the urethra, now no longer held forward by scar. To provide skin to cover the increased ventral length of the penis, and for future construction of an urethra, a graft is now brought down from the redundant dorsal prepuce. This is effected by, first of all, separating the two epithelial layers where the prepuce is reflected upon itself, thus increasing its length. Next, a buttonhole incision is made at the level of the corona (Fig. 3), and the glans brought through this; then the now circular margin of the buttonhole is sutured over a rubber catheter to the skin of the penis which was left posterior to the corona. A suture is placed through the ven-

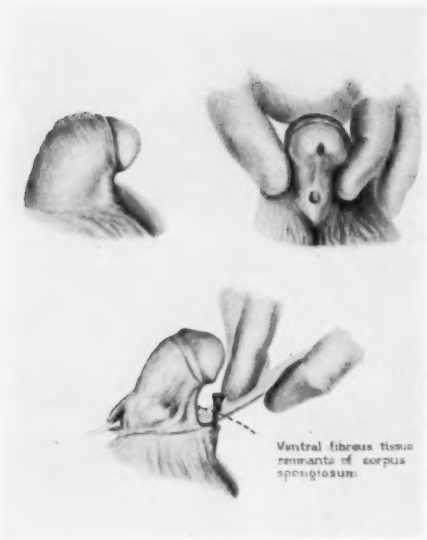

FIG. 1.

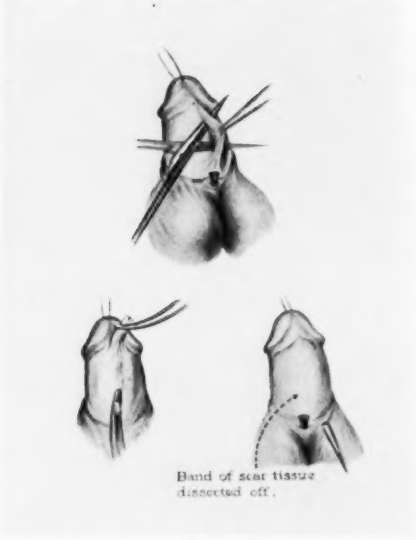

FIG. 2.

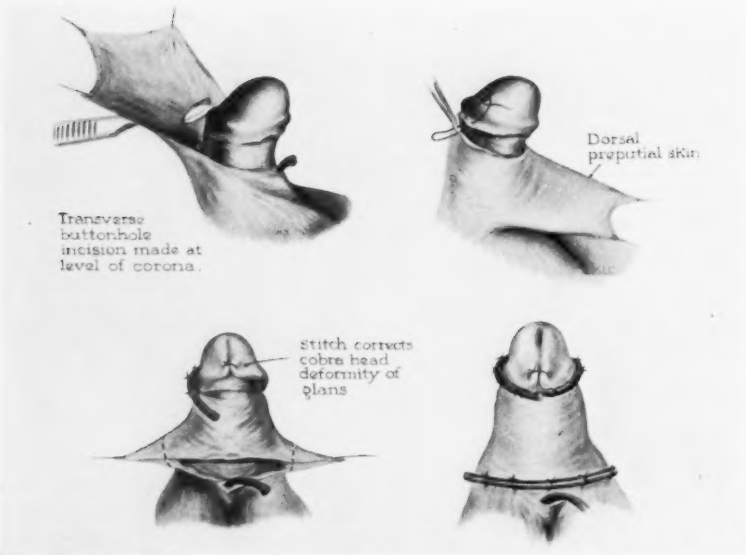

FIG. 3.

tral aspect of the glans to correct the flattened appearance. Finally, the border of the dorsal preputial skin is, likewise, sutured over a catheter to the margin of the ventral skin. An inlying catheter is left for a week to prevent the early contamination of the wound by urine.

In the cases in which we have employed this method, there has been no subsequent return of ventral scar tissue, with resultant chordee, and there has always been an abundance of cicatrix-free skin with which to carry out any type of urethroplasty desired at a later date.

THROMBO-ANGIITIS OBLITERANS

Clinical Observations and Arterial Blood Oxygen Studies During Treatment of the Disease with Sodium Tetrathionate and Sodium Thiosulfate

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IN THE TREATMENT of thrombo-angiitis obliterans, consideration should be given to the three factors in the pathology of the disease: (1) Biochemical blood changes; (2) peripheral thromboses resulting in circulatory deficiency, infarcts, and gangrene; and (3) local infection. For the pathologic blood condition, we have used intravenous injections of sodium tetrathionate ($Na_2S_4O_6 \cdot H_2O$) and sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$). Prior to 1937, only sodium thiosulfate was available for treatment of the pathologic blood condition. Since then, we have had prepared sodium tetrathionate which we have found to be slower in action but more prolonged in its effect than sodium thiosulfate.

In the acute cases, when the immediate effect of the medication is desirable, we alternate daily injections of the thiosulfate with the tetrathionate. As the acute stage subsides, we continue periodic biweekly, or weekly, injections of the sodium tetrathionate solution. The usual intravenous dosage which we have been using is 1 Gm. of the sodium thiosulfate and 0.4 or 0.6 Gm. of the sodium tetrathionate dissolved in 10 cc. of sterile distilled water. Transitory reactions may occur with either drug, but as a rule they are relieved by drinking a glass of water. We have observed no serious reaction in almost 8,000 injections.

Pavaex treatment is indicated for the circulatory deficiency resulting from arterial thromboses. These treatments, competently and adequately given, are beneficial in improving the peripheral circulation. In completely recovered cases, all treatment may be discontinued, but when smoking has been resumed, periodic injections should be continued. Local infection of the peripheral tissues is usually treated with hypertonic (25 per cent) magnesium sulphate dressings. Because of the success in the treatment of thrombo-angiitis obliterans with the inorganic sulphur compounds, some of our clinical observations and results of arterial blood oxygen studies were reported.

Eight case histories were used to illustrate the clinical course of the disease and the changes in the arterial blood oxygen which followed treatment. Oscillometric and stabilized peripheral temperature readings were taken on all patients. The patients were divided into two groups: (1) Without infection; and (2) with infection. Although the biochemical blood changes which followed treatment were fairly constant in the two groups, the clinical course differed because of the infection.

Bacteriologic studies of smears and cultures obtained from ulcerated or infected areas failed to account for the unusual features of these infections. A number of aerobic organisms were present either in pure culture or in a mixed infection. No anaerobic growths were obtained. *Streptococcus viridans* and *Staphylococcus aureus* were most frequently found, although organisms of *Escherichia*, *Pseudomonata*, *Staphylococcus albus* and *Corynebacterium* groups were occasionally present. An excised thrombosed dorsalis pedis artery (Case 1) did not produce bacterial growth on a number of culture media.

The clinical results in the treatment of more than 60 patients with thrombo-angiitis obliterans have been most encouraging, especially in view of the, heretofore, poor prognosis of the disease. We have observed numerous recurrences, but in every case smoking had been resumed, and it was possible that the treatment had been inadequate or prematurely discontinued. During the past seven years, six patients had minor surgical procedures and one required major amputation because of extension of serious secondary infection. Another patient, after a third recurrence of the disease, had a major amputation elsewhere, but he returned to us two years later with both hands and the remaining foot involved. Neither amputation nor sympathetic nerve operation had changed the course of the disease in the patients which we have observed.

The most constant chemical blood change which we detected was a deficient oxygenation of the arterial blood in the active stage of the disease. The percentage of oxygen saturation was especially low after smoking had been curtailed, or discontinued, and

was accompanied by low blood pressure, and by a slow pulse rate. The unusually low oxygen capacity in some acute cases occurred after heavy smoking. Some patients with thrombo-angiitis obliterans had erythrocyte counts from 4.5 to 6.0 million and colorimetric hemoglobin values of 75 to 95 per cent, with abnormally low oxygen capacities. The normal relation between the oxygen capacity and the colorimetric hemoglobin value usually returned after treatment with sodium tetrathionate or sodium thiosulfate, and with clinical improvement.

Clinical improvement accompanied the increased oxygenation of the arterial blood. From two to six weeks were usually required for complete relief from rest pains. This delay was probably due to the time required for readjustment in the systemic pathophysiologic changes which resulted from the low oxygenation of the arterial blood during the active stage of the disease. Although fairly normal oxygenation of the arterial blood may be present after the first few injections of the inorganic sulphur compounds, it seemed advisable to continue the treatment for many months. Smoking should be permanently discontinued, but it has been our experience that smoking was resumed by the large majority of these patients despite all advice and personal experience to the contrary.

The clinical results in the treatment of the biochemical blood changes in acute or active thrombo-angiitis obliterans with sodium tetrathionate or sodium thiosulfate and of the peripheral circulatory deficiency due to arterial thromboses with Pavaex treatment have been most encouraging. Deficient oxygenation of the arterial blood was usually present during the active stage of the disease. Following treatment for two to six weeks, the increased oxygenation of the arterial blood was accompanied by clinical improvement. The oxygenation of the arterial blood, in the majority of patients with thrombo-angiitis obliterans which we studied, was affected by smoking.

DISCUSSION.—DR. LAWRENCE FALLIS (Detroit): I should like to ask Doctor Theis if he has had any experience with these cases of migrating phlebitis of the leg in young people, where you cannot make a definite diagnosis of thrombo-angiitis obliterans. We have seen a student who gave a history of having had phlebitis over a number of years which cleared up spontaneously, no faster with our treatment, and recurred within a short period of time.

DR. FRANK V. THEIS (Chicago, closing): We have had an opportunity to follow a few cases of migrating phlebitis. These patients had a low oxygen saturation of the arterial blood, and some of the other blood changes which we observed in thrombo-angiitis obliterans. We have had some excellent results in treating them the same way, with the inorganic sulphur compounds, that we treat the blood changes in thrombo-angiitis obliterans. The results of some of our other blood studies, in patients with migrating thrombophlebitis, fit in very well with our blood findings in thrombo-angiitis obliterans.

DR. HENRY H. HARKINS (Detroit): I should like to ask Doctor Theis if he has had any experience with lumbar sympathetic injections in these cases and if he has made any concurrent blood chemical studies.

DR. FRANK V. THEIS (Chicago, closing): We have had an opportunity to see a few patients who have had such injections, and these have had intractable pain. Our blood chemistry studies have not covered these patients, as we are now primarily interested in studying acute cases. We have preferred to make blood chemistry studies on new cases, especially those who have had no previous treatment. Without initial blood studies, two patients who had received lumbar sympathetic alcohol injections elsewhere were treated by us in the same way as other patients with thrombo-angiitis obliterans. No improvement occurred in the intractable leg pains which continued after the alcohol injections.

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INDIVIDUALIZATION IN THE SURGICAL TREATMENT OF VARICOSE VEINS

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THE TREATMENT OF VARICOSE VEINS has long been considered of minor consequence. In general, it has been relegated to younger surgeons or physicians. As a result, either a stereotyped operation is performed or sclerosing solutions are injected, with little previous study of the problem involved.

We present a series of operations performed by the senior author (Henry N. Harkins), or under his direct supervision, during a one-year period, January 13, 1940 to January 13, 1941. Ninety-eight legs on 63 patients were operated using his methods. This report does not pretend to be a follow-up review, but simply presents the methods and immediate results obtained.

The following diagnostic tests were employed before surgery or other treatment was instituted:

(1) Inspection and palpation of the veins.
(2) Schwartz test.
(3) Perthes test.
    (a) With tourniquet.
    (b) Tight bandage test of McCallig and Heyerdale (1940).
(4) Trendelenburg test.
(5) Ochsner-Mahorner (1938) multiple tourniquet test.
(6) Cough impulse test (Adams, 1939).
(7) Harkins test.

This last is a local Ochsner-Mahorner test which gives horizontal as well as vertical localization. It is employed in the following manner after the O.M. test gives the level of the lowest perforator. The most suspicious vein at this level is compressed by the finger of the examiner and the patient instructed to step alternately back and forth with this leg while the other leg remains stationary. Collapse of the vessel below the point of pressure indicates the level and the offending vein with which the lowest perforator communicates.

Injection Treatment.—Eighty varicose vein patients were seen during the year. Five were advised to have injections alone, 12 to have ligations, but did not accept operation, and 63 were operated upon, and form the basis for this study. Patients with active phlebitis were given palliative treatment.

Injection therapy was started with an initial small (1 cc. or less) desensitizing dose. If a patient stayed away more than seven days, the series was begun over again with the small dose. This procedure was based on the principle that anaphylactic sensitivity usually takes seven to ten days to develop.

Injection alone was reserved for cases with:

(1) No palpable or superficial veins above the knee.
(2) Patients with a normal Trendelenburg.

Postoperative Injections.—Twenty-eight cases received an average of 4.7 injections per case. Our injection technic is to wait ten days after surgery before giving the initial desensitizing dose. The amount is then worked up to but never exceeds 5 cc. For large veins, we use the "Elastoplast Technic" of injection, *i.e.*, a piece of elastoplast (4x6 inches) is split vertically for 2 cm. in its center and spread tightly over the site of injection. The injection is given through the opening. Patients rest horizontally for 20 minutes after injection and then walk away from the office.

Injection at the time of operation was abandoned after trial for the following reasons:

(1) The pain of injection is worse than that of the operation and is apt to cause the patient to go to bed—with subsequent danger of embolism.
(2) A large dose (5 cc.) of sodium morrhuate is necessary to be effective. This is dangerous with-

out an initial desensitizing dose. Preoperative desensitization may produce inflammation of the vein which frequently makes the operation difficult.

(3) Secondary incisions lower on the extremities cannot be made without danger of leak of the injected fluid.

(4) If time is allowed for the veins to collapse following operation, less substance will need to be injected later.

Operative Treatment.—It was insisted upon that all patients remain ambulatory following surgery. All cases except one (this due to length of procedure) had a high saphenous ligation. This was usually supplemented by one or more ligations or excisions lower down on the thigh or leg.

True lesser saphenous veins were found in three of the 98 cases.

OPERATIVE TECHNIC

Hospitalization—Majority of patients treated as out-patients.

Anesthesia—Local ½ per cent novocain in all cases except one. General used here because of hysteria of the patient.

Skin preparation—Veins marked with gentian violet with patient in upright position. Preparation with iodine. Genitals prepared with aqueous solution of hexylchloro-M-cresol.

Ligatures—Silk used exclusively.

Incisions—Fossa Ovalis—parallel and below Poupart's ligament. Lower Incisions—Usually longitudinal, made over veins. Transverse incisions made for exit of stripper.

Stripping—Done as an ambulatory procedure. We never strip the six inches of vein just below Poupart's ligament. Accurate marking and skin novocainization make it a painless procedure. It is our policy to bring the stripper to the surface and ligate a perforator when we come in contact with one. Bleeding is controlled by elastoplast, under which we have never had an hematoma.

Dressing—Small sterile gauzes adequately covered by adhesive or elastoplast.

Postoperative orders—"Seven-hour rule"—patients are to remain in bed no longer than seven hours at one time for two weeks.

SUMMARY.—In a series of varicose vein operations, personally conducted upon 98 extremities of 63 patients, during 1940, 227 incisions and 19 strippings were undertaken.

CONCLUSIONS

(1) A stereotyped operation should be avoided. The surgical procedure should be individualized to fit the patient, and to block all important venous incompetencies as determined by complete diagnostic tests.

TABLE I

SYNOPSIS OF MATERIAL UPON WHICH THIS STUDY IS BASED

Total number of cases—63
Total number of lower extremities operated upon—98

Sex Incidence	Age Incidence
Males —28	Ages varied from 20 to 70 yrs.
Females—35	63% of group between 40 and 55 yrs.

Side Incidence	Duration of Symptoms
Left —56	Ranged from 3 mos. to 55 yrs.
Right—42	Average duration, 16.3 yrs.

Severity of Symptoms

Preoperatively	Postoperatively
22 cases of ulcer	1 unhealed ulcer in the group
Majority of cases rated ++ to ++++ as regards pain, swelling, and appearance.	5 cases rated any one of their symptoms + or better.

Previous Treatment

Previous surgery—7
Previous injections—21
Average number of injections per patient—13.8
All other methods of treatment represented

Postoperative Complications

Minor stitch infections—8
Infected wounds—1
Seromata—2
Keloid formation—1
Postoperative bleeding—6
Severe requiring reopening—3
Hematomata—3

Number of Incisions

Left —129	Incision below knee—31
Right— 92	Incision below knee prior to 7/13/40—2
Total—221	

Stripping

19 cases
Prior to 7/13/40—4 cases

Postoperative Injections

Cases necessary to inject—27
Average number of injections per case—4.7

(2) High ligation and segmental excision of the saphenous vein and all its branches at the fossa ovalis should be performed in all cases submitted to surgery.

(3) Additional ligations and excisions lower down on the thigh or leg should be performed as indicated.

(4) Stripping gives a better cosmetic result than excision and is preferable to the latter except in cases of superficial, friable, or recently sclerosed veins, and for veins high in the thigh.

(5) Injection as an adjunct to surgery is best postponed until the second week after operation.

(6) Important points in the surgical technic include the use of local anesthesia, silk, transfixion of main vessels, elastoplast bandages, and ambulatory care in all cases.

(7) The one ill-effect of consequence in these cases was a slight increase in edema of one leg in two cases and a marked edema in another case.

DISCUSSION.—DR. CONRAD R. LAM (Detroit): I should like to ask Doctor Harkins why he does not inject sodium morrhuate at the time of operation. I had understood that the current belief in regard to the treatment was a combination of operative and chemical treatment at the same time.

DR. HARKINS (closing): Formerly, I injected all my cases at the time of operation, but have changed my mind for several reasons: First, to be effective, the dose has to be quite large, and if the patient is prepared for this large dose beforehand, the preoperative injection is apt to cause difficulty with the operation. If the patient is not prepared beforehand, reactions may occur. Then, furthermore, since, in so many of my cases, I make additional incisions down below, which I believe remove incompetent perforators better than injections would, the injection of fluid above is apt to leak out when these lower incisions are made.

The third objection to injection at the time of operation is that the pain from such an injection, and I can speak to some extent from experience, is so much more severe than the pain from operation alone that the patient is apt to go to bed, and since I believe that the main element in preventing postoperative embolism is the ambulatory treatment, I do not want to do anything that would interfere with the patient's being up and about.

Finally, I believe that these patients, if they are not injected until a couple of weeks afterward, will have much smaller veins due to the collapse from the operation. Thus, much less sodium morrhuate need be injected at that time.

AN ANATOMIC ERROR IN CURRENT METHODS OF INGUINAL HERNIORRHAPHY

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ALL METHODS OF INGUINAL HERNIORRHAPHY with which the author is familiar have one feature in common: that the various inguinal layers are sutured to the inguinal ligament. This is the error referred to in the title. There are not only many inconsistencies but many errors in the standard descriptions of inguinal anatomy. This broad statement is based upon a dissection of over 300 inguinal regions. These observations have been presented in detail elsewhere; suffice it to say that there is no anatomic justification for suturing the transversalis fascia or any of the other inguinal strata to the inguinal ligament. The latter serves neither as origin nor insertion for the transversus abdominis and internal oblique layers, its relationship being simply one of contiguity.

Whenever possible, in the field of surgery, one attempts to restore normal anatomic continuity, and it is the plea of this article that this fundamental principle be observed in the repair of inguinal herniae. In other words, after excision of the hernial sac, the transversalis fascia, the aponeurosis of the transversus abdominis muscle, and the aponeurosis of the internal oblique muscle (when present in this location) should be sutured, not to the inguinal ligament, but to Cooper's ligament. The inguinal ligament is a frail, friable structure, easily elevated from its fascial bed and in no way a suitable substitute for the normal anatomic insertion—which is Cooper's ligament.

Cooper's ligament is no newly discovered structure but one that has been used in the repair of femoral herniae for many years. It is a thick, very tough, ligamentous structure lying on the superior ramus of the pubis and extending from the pubic tubercle medially to the vicinity of the femoral vein

laterally. It is to this ligament that the inguinal layers should be sutured.

A detailed account (with illustrations) of the operation recommended is shortly to be published and, so, for the present purposes, only a summary will be given. In any inguinal hernia where the posterior wall of the inguinal canal is either encroached upon by an indirect inguinal hernia or attenuated by a direct inguinal hernia, the following operation is performed. After disposing of the hernial sac in the accepted manner, weak or attenuated aponeuroticofascial layers are excised, and the strong aponeurotic margin of the transversus and internal oblique layers (with underlying transversalis fascia) is sutured to Cooper's ligament from the pubic tubercle medially to the femoral vein laterally. Fascial continuity is reconstructed over the femoral vein up to the abdominal inguinal ring by suturing the transversalis fascia to the anterior layer of the femoral sheath; then, after the abdominal inguinal ring has been reduced to normal size, the spermatic cord is dropped back into its normal position and the external oblique aponeurosis closed with the cord emerging through the subcutaneous inguinal ring. The fact that this operation restores inguinal anatomy to normal is the justification for its presentation. A sufficient follow-up interval will evaluate the procedure.

THE PROPHYLAXIS OF HUMAN BITE INFECTIONS

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BECAUSE of the spreading tendency of established infections caused by human acclimated organisms, prophylaxis is of major import. An understanding of the problems involved was clarified in 1930 by Mason and Koch who described the pathogenesis of human bite infections.

There appears to be universal agreement among authors as to the bacteriology. The importance of recognizing the depth of penetration of laceration is pointed out; this is frequently difficult to determine, especially in small penetrating wounds. The extent of injury to the tendon, bone, and joint cavity, should be determined at the primary examination.

Believing the results obtained by those surgeons using chemical and electrocautery methods in the primary treatment of these wounds are not entirely satisfactory, we have, in our clinic, followed the suggestion made by Mason and Koch, in 1930, of cleansing the wound with soap and water, combined with gentle débridement. The recognition of early human bites, as such, is often quite difficult. Falsification of history is common, especially in the white patient, and often results in ill-advised primary suture. A definite and comprehensive regimen has been developed, comprising a searching history, complete examination, and treatment.

The routine treatment employed is as follows: The area about the wound is gently washed with soap and water for five minutes, following which the wound itself is thoroughly washed and irrigated with saline for a further period of ten minutes. Following the above procedures, the edges are gently retracted and the lesion examined, in order to determine the extent of injury. These wounds are not probed, since the information obtained is meager and the danger of carrying infectious agents more deeply into the tissues is great. Following mechanical cleansing, a limited debridement is performed and wet dressings are applied. No attempts are made to repair the rent in the joint capsule. Hands are splinted in the position of function. Lacerations are never sutured nor are injuries to deeper structures repaired. The major catastrophes in our series have occurred in those cases primarily sutured. All compound fractures in association with human bites are hospitalized for observation.

We have observed and given prophylactic treatment to 61 early human bites. As an arbitrary time, we have included in this series all cases seen within four hours after the occurrence of injury. Those cases already presenting swelling and evidence of infectious extension were not included in this series even if within the four-hour period. Of these 61 cases, mild inflammatory reaction, characterized by swelling and tenderness without suppuration, was noted

in five cases, two occurring on the knuckle, two on the fingers, and one in a compound fracture. The two inflammatory knuckle injuries were primarily sutured as there was falsification of history. The average healing occurred in eight days.

The after-care consisted essentially of splinting and the application of continuous saline, boric acid, or magnesium sulphate soaks for a period of 48 hours. The wet dressings were discontinued at this time if the wounds remained clean.

This simple procedure has, in our series of cases, given results which have been most gratifying. Unfortunately, the patient, when first seen, often has a fully established infection and, regardless of the adequacy of treatment, frequently is condemned to a prolonged illness which may result in loss of parts and occasionally life.

BENEFICIAL EFFECT OF OXYGEN THERAPY IN SHOCK

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ANOXIA plays an important rôle in the development and augmentation of shock. One might expect anoxia to be present during shock on the basis of a fall in blood pressure (stagnant anoxemia); reflex inhibition of the depth and rate of respiration (anoxic anoxemia); a loss of oxygen-carrying hemoglobin (anemic anoxemia); and with the administration of barbiturates to allay the restlessness (histiotoxic anoxia). This work was done to determine whether anoxemia was present during traumatic shock, and what effect the continuous inhalation of high oxygen concentrations had upon shock due to trauma, histamine, and hemorrhage.

A decrease in the oxygen content and saturation of blood from the femoral artery and vein was present in nembutalized dogs in traumatic shock. Oxygen therapy significantly increased the oxygen in the arterial and venous blood.

While the degree of trauma, as indicated by the average amount of fluid loss into the injured limb, was the same in ten control dogs breathing atmospheric air (4.26 per cent of the total body weight), and the ten dogs treated with inhalation of 100 per cent oxygen (4.11 per cent of the total body weight), the average length of life of the control dogs was 4.5 hours and those treated with oxygen was 7.7 hours. Thus, oxygen therapy caused a 70 per cent increase in the length of life of dogs in traumatic shock. The blood pressure of the dogs treated with oxygen was higher four, six, and eight hours after the trauma than the untreated group.

Oxygen increased the length of life of ten dogs in histamine shock (blood pressure continuously maintained at about 40 Mm. of mercury) by 71.7 per cent. The control dogs lived 5.6 hours and the treated dogs 9.8 hours.

Loss of blood by repeated hemorrhage equal to 2 per cent of the body weight in the ten control dogs caused a 54 Mm. of mercury fall in the blood pressure and only a 35 Mm. fall in the ten dogs treated with oxygen. After a blood loss of 4 per cent of the body weight, the blood pressure of the control dogs was 35 Mm., and of the treated dogs 39 Mm. of mercury. Oxygen therapy enabled the treated dogs to withstand a 15 per cent greater blood loss (4.82 per cent of the body weight) than the control dogs (4.19 per cent of the body weight). It also resulted in a 17 per cent increase in the length of life of the treated dogs (3.60 hours) over that of the control dogs (3.08 hours). Oxygen therapy did not have such a marked effect upon prolonging the life of the dogs in shock due to hemorrhage, because of the large loss of oxygen-carrying hemoglobin in these dogs.

Increased hematocrit readings, indicating hemoconcentration, were observed in all three types of shock.

Inhalation of high oxygen concentrations has a beneficial action upon shock due to trauma, histamine, and hemorrhage.

EXPERIMENTAL WORK ON ALIMENTARY AZOTEMIA

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In the past six years, several authors have reported an increase in blood urea nitrogen in certain cases of bleeding peptic ulcer. The chief theories to explain this increase were dehydration, shock, hepatorenal damage, hypochloremia, starvation, and absorption of digested blood. The mechanism of this syndrome is of considerable clinical importance because if the azotemia is due to renal damage or like causes, operation might be deemed contraindicated. If, on the other hand, the phenomenon is merely caused by absorption of lost blood, its presence might be an indication for operation, other things being equal. To help elucidate this matter, the following experiments were performed:

Effect of Whole Blood.—Blood was given by stomach tube to normal dogs and blood urea determinations made for several days, at four- or six-hour intervals. A marked rise occurred at about the tenth hour after blood administration. Additional experiments on rats showed a similar elevation. Intraperitoneally administered blood was without effect.

Effect of the Level in the Intestinal Tract.—When the blood was given by stomach tube or jejunostomy, a marked rise in urea occurred, but when given by low ileostomy, little effect was produced.

Relative Effects of Plasma and Red Cells.—Red cells were found to give a much more marked effect than plasma, the difference being approximately proportional to the protein content. Pure hemoglobin solution as well as protein mixtures were especially active while iron was inactive.

Rôle of the Liver.—In a series of dogs with reverse Eck fistulae, the rise in blood urea following intragastric blood or red blood cell administration was even more marked than in normal animals, while in dogs with Eck fistulae, practically no rise occurred. In hepatectomized dogs the urea (as well as the plasma prohrombin) fell.

CONCLUSION.—The intragastric or intrajejunal administration of blood caused a uniform and considerable rise in blood urea nitrogen in normal and reverse Eck fistula dogs. This rise seemed due primarily to the absorption of digested blood protein. The term "alimentary azotemia" is proposed for this syndrome. It seems logical to assume that much of the rise in blood urea nitrogen observed in clinical cases of bleeding peptic ulcer is due to the same phenomenon.

THE FUNCTIONS OF THE ANESTHESIOLOGIST IN THE SURGICAL TEAM

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ALTHOUGH ANESTHESIA was introduced by physicians and treated in its early stages as a scientific branch of medicine, the relegation of its clinical application to technicians has retarded its proper development, and hampered the surgeon in his efforts to improve and extend the scope of surgical therapy.

The interest of the physician in anesthesia as a profession has been recently stimulated, and there is recognition by surgeons of certain specific functions of the anesthesiologist in the surgical team. These functions, of which there are five, combine to provide the best anesthesia for patient and surgeon. The functions are: (1) Premedication. (2) Individual selection of agent and technic. (3) Technical application. (4) Postanesthetic responsibilities. (5) Records and research.

Premedication is a misnomer. The nonvolatile drugs administered to the patient preoperatively are actually a part of the anesthesia. They produce definite phar-

macologic actions, and must be administered as intelligently as any other anesthetic agent. As a consequence, these drugs should be ordered by the anesthetist with direct reference to the anesthesia to be employed.

In selecting the proper agent and technic, each case must be individualized. The routine use of certain agents and technics will prove unsatisfactory. To select intelligently, the anesthesiologist must know the requirements of the surgery and the physical state of the patient.

The technical administration of anesthesia is a function which reflects the anesthesiologist's knowledge of the fundamental factors affecting that anesthesia. The "giving of an anesthetic" is no longer a matter of routine by rote, but a continuous evaluation of the patient's response to anesthesia and surgery.

The training of the surgeon is easily demonstrated at the operating table. So, also, is the training of the anesthetist evident in increased safety to the patient and convenience to the surgeon.

The anesthesiologist can be of service to the patient in the postoperative period by assisting in the maintenance of a free airway, in problems of sedation, and in problems of drug depression.

In order to complete his functions, the anesthesiologist must keep records for critical and accurate evaluation of the anesthetic procedures employed. He must also contribute to the advancement of the science by clinical and laboratory research.

The functions of the anesthesiologist, then are the functions of a scientist and a physician. The scientific rather than empiric approach to the problem of anesthesia is reflected in lowered morbidity and mortality and greater convenience to the surgeon.

DISCUSSION.—DR. J. C. SCHNEDORF (Kansas City, Kan.): I should like to ask Doctor Cullen whether barbiturates are indicated in the convulsions from other anesthetics known to produce a definite arterial oxygen desaturation when barbiturates are used.

DR. STUART C. CULLEN (Iowa City): The first indication in any convulsive reaction, of course, is oxygen. Oxygen must be supplied, no matter what drug is used, to combat the convulsion. If the convulsion cannot be controlled by the administration of oxygen and the proper elimination of carbon dioxide, certainly by some means the convulsion must be stopped, and an intravenous barbiturate is the ideal agent. I should like to emphasize that oxygen is the first requirement. I know of no reason for barbiturates causing a reduction in the arterial oxygen saturation, unless there is mechanical obstruction to the entrance of oxygen into the alveoli or depression of the respiration. I do not believe that the barbiturates in themselves can cause arterial oxygen desaturation.

DR. ARTHUR MCGRAW (Detroit): I wanted to ask Doctor Cullen how the various barbituric agents serve to protect one against toxic activities of other anesthetic agents.

DR. STUART C. CULLEN (Iowa City): It has been demonstrated in the laboratory, and is evident in the clinic, that barbiturates protect against the convulsive manifestations of the toxic reactions of cocaine and cocaine derivatives. Cocaine and cocaine derivatives stimulate the hypothalamus, and the barbiturates depress it. The evidences of that type of action have been much diminished, and even eliminated, in certain cases by the use of barbiturates.

CESSATION OF RESPIRATORY EXCHANGE

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THE ANESTHETIST has almost constant occasion to observe respiratory problems and it, therefore, seems to be within his province to offer his views on this subject. The term cessation of respiratory exchange is used here to refer to complete interruption of the flow of air into and out of the lungs.

Adequate respiratory exchange is essential to life, but cessation of respiratory exchange is not immediately synonymous with death. Indeed, it need not cause undue alarm since it need rarely prove fatal, provided it is promptly recognized, quickly investigated, and judiciously treated. Failure to breathe is no more synonymous with death than is failure to eat. Either condition if allowed

to persist will cause death from deprivation, and the urgency in each case depends on the amount of reserve supply in the body at the time. The conclusion is obvious. *In case of cessation of respiratory exchange, supply oxygen (air) and save the life.*

Interference with respiratory exchange should be considered a mechanical problem and treated by mechanical means. On a mechanical basis, to facilitate quick diagnosis and treatment, the condition may be divided into three classes:

I. CESSATION OF RESPIRATORY EFFORT WITHOUT OBSTRUCTION.—This is recognized by absence of spontaneous respiratory movement, while efficient artificial respiration can inflate the chest. It may be caused by (1) paralysis of the muscles of respiration; (2) excessive elimination of carbon dioxide; (3) reflex inhibition; or (4) paralysis of the respiratory center, as from overdose of anesthetics, or from acute oxygen want. The immediate treatment is establishment of *efficient* artificial respiration, to be accompanied by efforts to eliminate the cause.

II. OBSTRUCTION TO RESPIRATION WITHOUT CESSATION OF RESPIRATORY EFFORT.—This is recognized by failure to get air into the lungs while active respiratory movements persist. It has a characteristic appearance which must be recognized or it may be overlooked until acute oxygen want becomes evident. Among the common causes are (1) falling back of the tongue; (2) foreign bodies; (3) laryngospasm; (4) tumors or edema; and (5) external pressure on neck or chest. Treatment entails removal of the cause, if possible. The insertion of a metal pharyngeal airway or an endotracheal catheter may relieve some types of obstruction. Postural drainage or suction may remove fluids such as vomitus. In some cases, air may be successfully blown past an obstruction by positive pressure methods. Tracheotomy may be advisable in a few cases.

Since oxygen want rapidly ensues, paralysis of the respiratory center may follow, requiring artificial respiration.

III. CESSATION OF RESPIRATORY EFFORT AND OBSTRUCTION TO RESPIRATION.—This is a combination of the first and second types most commonly caused by acute oxygen want following obstruction, or by relaxation (and pharyngeal obstruction) resulting from the same depression which paralyzes the respiratory center. The treatment requires relief of obstruction followed by artificial respiration.

Artificial Respiration.—Manual methods may suffice, but mouth to mouth, or mouth to nose breathing are particularly convenient and effective. Anesthesia apparatus provides a means of inflating the lungs by positive pressure.

Stimulants.—The administration of analeptics or of inhalations of carbon dioxide, or of intracardiac injections of adrenalin are of little or no value.

Finally, every doctor should be capable of dealing with acute respiratory emergencies without the aid of the fire department.

DISCUSSION.—DR. J. C. SCHNEDORF (Kansas City, Kan.): I should like to ask Doctor Cassels whether he means what he said, that during certain conditions of asphyxia the blood carbon dioxide is already high, and the administration of more CO_2—for example 5 per cent CO_2 and 95 per cent oxygen—is of no use. This totally disregards the experimental evidence, which shows that beneficial action of carbon dioxide is there, as shown by Henderson.

DR. W. H. CASSELS (Chicago, closing): I meant what I said. Blood analyses have shown that the carbon dioxide content of blood is raised in practically all anesthetic procedures. There used to be a misconception, based on the idea that ether anesthesia caused hyperpnea. We will grant perhaps there is an hyperpnea during induction, but in most cases it goes on to a depression of respiration. Also, most technics involve some dead space, which adds to the accumulation of carbon dioxide. When breathing stops, of course, there is still some production of carbon dioxide, which goes on to add to the difficulty.

It has been shown in other experiments that carbon dioxide is harmful in resuscitative processes. I might refer you to work done by Eastman and Kreiselman, in which they used various concentrations of oxygen and carbon dioxide, from 99 per cent oxygen and 1 per cent carbon dioxide up to much higher concentrations of carbon dioxide, in resuscitating animals asphyxiated with nitrous oxide. Their results uniformly showed that the addition of carbon dioxide was harmful.

I might also encroach upon the question addressed to Doctor Cullen and point out that high carbon dioxide probably plays a part in the production of anesthetic convulsions, and that the use of carbon dioxide for resuscitative measures is apt to produce convulsions.

THE PROBLEM OF CATGUT SENSITIVITY AND ITS RELATIONSHIP TO WOUND HEALING

A Preliminary Report

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EXPERIENCE with thoracoplasty wounds reveals that healing is quite often unsatisfactory and complications are annoyingly frequent. Some of these failures to heal kindly may be attributable to the abuses suffered by these wounds.

Comparison of such wound sutured by a bulk stitch of catgut with those closed by careful silk technic reveals a remarkable preservation of the fascial planes in the latter when reopened for a subsequent stage, as contrasted to the widespread obliteration of these layers and its replacement by heavy edematous scar in the former. Thus, the suture material seems highly important in the process of healing, in these wounds.

An extract of catgut was prepared, and all patients currently admitted to the service were skin-tested, observing the usual procedures of such tests. A total of 54 patients received 113 skin tests. The results are graphically shown by Curves 1 and 2 of Chart 1. Curve 1 represents the percentage of reactions positive in any degree, obtained at each indicated period in the evolution of the thoracoplasty. Curve 2 represents the percentage of reactions that were highly positive at the same periods. The peak of sensitivity occurs after the second stage. The appearance of the wound was found to directly reflect the severity of the skin test reactions preoperatively. The wound complication that appears to

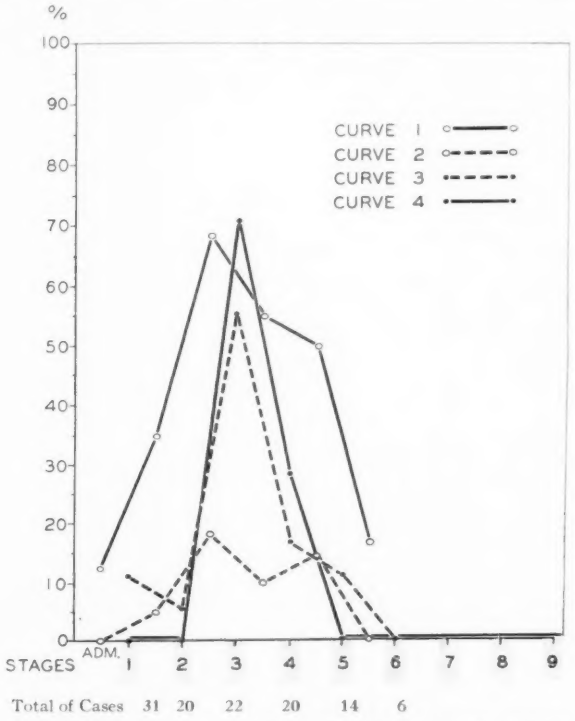

CHART 1.—Curves 1 and 2: Graphic representation of the degrees of sensitivity occurring during various stages of thoracoplasty; and, also, the incidence of infection (Curves 3 and 4)—Demonstrating a remarkable correspondence between the two.

be a direct sequela to this reaction, is a separation of the wound edges when some of the skin sutures (silk) are removed routinely on the fifth day. The linear extent of this separation is determined by the remaining skin sutures.

Although diligently sought for, passive transfer of antibodies and precipitins, in blood serum as well as wound serum, could not be demonstrated. This suggests that the reaction is confined to the skin and/or muscles as a local manifestation, or in these tissues as a specific reacting system.

The patients were investigated for speed with which the catgut underwent lysis and, although fragmentary, the data suggest that the rate of lysis is proportional to the degree of sensitivity.

In order to ascertain the possible influence of sensitivity upon wound healing, a group of 184 consecutive thoracoplasty wounds were studied, and the incidence of complications plotted by stages. These are represented by Curves 3 and 4 of Chart 1. Curve 3 represents the percentage of all complications by stages. Curve 4 represents the percentage of complications exclusive of frank infections at the same periods. Eighteen complications, or a 9.7 per cent incidence, were recorded. Of these, 11 or 5.9 per cent were infectious (Staphylococcus aureus, or tubercle bacilli); seven or 3.8 per cent, were of other types. These corresponded to the above described sequela to catgut sensitivity.

Superimposing these curves, strikingly presents their similarity. There were a total of 12 operations beyond the fifth stage, without complications.

Thus, evidence has been presented that:

Sensitivity to catgut used in rather large doses, and repeatedly, can be demonstrated by means of a skin test, and the curve of the sensitivity closely corresponds to the immunologic response to the commonly used antigens.

It is intimated that, in sensitized individuals, lysis of the suture material occurs more rapidly than in the nonsensitized person.

The sensitization to catgut appears to be a purely local reaction, confined to the tissues as a reacting system, since no evidence of systemic response has been seen.

When the wound complications occur, they do so with amazing frequency at a period in the evolution of the thoracoplasty when sensitivity is highest, as demonstrated by skin tests. It is believed that in presence of a hypersensitive response to catgut, the fundamental difficulty is a delay in the fibroblastic phase.

The exact component of a catgut suture which acts as an antigen cannot be determined from this study alone.

The skin test has no practical significance in sorting suitable candidates for catgut closures, because it is often only after one or two stages that sensitivity becomes demonstrable.

TWO DISTINCT TYPES OF DEHYDRATION*

A Preliminary Report

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AS SEEN CLINICALLY, dehydration is of two main types or some combination of the two, depending upon whether it is due to (1) shortage of water; (2) shortage of electrolytes; or (3) to both of these factors working simultaneously. As shown in rabbits, by Kerpel-Fronius[1] in 1935, these two types are not merely slight variations of the same thing but are essentially different conditions. They differ in mechanism of production, in symptomatology, and in the treatment indicated.

The contrast between the two types is well shown in the following four experiments which were performed upon normal human subjects.

In the first two experiments, the subjects swallowed Miller-Abbott tubes, the tips of which were passed into the jejunum and allowed to remain there for four or five days while constant suction was applied. The urinary output was kept at a normal

*This investigation was aided by a grant from the Horace H. Rockham School of Graduate Studies.

level by the daily administration of salt-free water.

As a result of the Miller-Abbott suction, one subject lost 8.4 Gm. of sodium and 13.9 Gm. of chloride (equivalent to a loss of about 22 Gm. of NaCl). The other subject lost 9.0 Gm. of sodium and 15.6 Gm. of chloride (equivalent to approximately 24 Gm. of NaCl). Both subjects lost weight, developed weakness, apathy, anorexia, hypotension (80 and 85 Mm.Hg. systolic pressure, respectively), and orthostatic fainting. Both showed a marked hemoconcentration, with rise in hematocrit and in plasma protein concentration. So-called "classic signs of dehydration" such as thirst and oliguria were entirely absent. Administration of salt-free water had no effect in alleviating this condition, but Ringer's solution brought about prompt and complete recovery.

In the third and fourth experiments, the subjects were dehydrated by means of water deprivation. The subjects lost weight, developed marked thirst, oliguria, and azotemia. They did not excrete a significantly increased amount of sodium or chloride in the urine. There was no significant hemoconcentration, mental apathy or anorexia. Administration of distilled water resulted in prompt recovery, in contrast to the findings in the first two experiments.

The essence of the "salt-loss" type of dehydration, we believe, is a reduced volume of extracellular fluid.[1, 2, 3] This change is well reflected in the plasma by hemoconcentration. The symptoms are those seen in impending shock and are undoubtedly due chiefly to the reduction in blood volume and corresponding circulatory impairment.

The essence of the "water-loss" type of dehydration (true dehydration) is a simple shortage of body water in relation to the quantity of solutes present in this water.[1] This concentration of solutes is associated with thirst.

The clinical counterpart to these experiments is evident. In diarrhea, in various types of intestinal fistulae, in profuse sweating, and in Addison's disease we often find the extracellular type of desiccation in its pure form. In marked dysphagia, or any condition giving rise to simple water deprivation, we find true dehydration in the literal sense. In severe vomiting from any cause, we generally encounter a mixed type of dehydration, because a vomiting patient is likely to have both a restricted intake of water and also an abnormal loss of electrolytes. The therapeutic implications are obvious. To correct thirst, oliguria, and extrarenal azotemia, water or glucose solution is needed. To correct manifestations of extracellular desiccation, saline fluids are needed. Since many patients have both forms of dehydration, both of these types of fluid are frequently needed. We have many times emphasized the need for choosing the proper kind and amount of each solution and have developed simple rules for their selection.[4]

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BOOK REVIEW

FIELD SURGERY IN TOTAL WAR. By DOUGLAS W. JOLLY, M.B., Ch.B.N.Z., Late Major, Spanish Republican Army Medical Service; with a Foreword by SURGEON REAR-ADMIRAL G. GORDON-TAYLOR, O.B.E., M.A., F.R.C.A., F.R.A.C.A. Published by Paul B. Hoeber, New York City.

THIS BOOK, written by a late major in the Spanish Republican Army Medical Service, bears the impress of experience, for the casualties which passed through his hands were the gravest type of injury and embraced the treatment of some 5,000 wounded men. No British surgeon before the author of this book, and probably no surgeon at any rate, has ever personally operated upon almost 1,000 gunshot wounds of the abdomen.

It is for these reasons, which have been expressed by Surgeon Rear-Admiral G. Gordon-Taylor, that we offer this review at this critical time, for it would seem that the Medical Corps Field Service School would do well to study this work carefully, with the object of modifying our present organization. Jolly comments on the surgeon who uses Dakin's solution as a "1914–1918 model," so in a way is the operation of our own evacuation system outdated.

A criticism of the "Three Point System" may be the question of whether it is possible to normally keep patients in these advanced stations for eight or ten days before evacuating them. However, the success of the plan in Spain was marked, and a lesson that certainly might be well taken by our Army is the location of the echelons of evacuation with the five-hour, ten-hour and 18-hour lag-periods, following the receipt of a wound, rather than by the fixed distance of miles. *The lag-period between the sustaining of the wound and the surgical intervention,* from Jolly's experience, is the crux of the organization of the Medical Corps of the Army in the field.

Another feature, which Jolly seems to demonstrate, is the importance of the Classification Hospital, with routings to the Hospital for Immediate Operations (called the No. 1), or to Hospitals for Intermediate Priority and Special Attention (the No. 2), and finally the more trivial cases needing hospitalization being directed immediately to the Evacuation Hospital.

Among the outstanding contributions of this experience of Jolly there may be mentioned the following:

(1) The well-controlled use of glucose and saline in the treatment of shock.

(2) The general use of blood, which in our more "expensive" war, may be supplemented by plasma or serum, frozen or dry.

(3) Instructions to litter bearers in the handling of the suspected spine injury-abdominal cases to place them in the prone position, and in hyperextension aided by the sag of the stretcher canvas.

(4) The use of plaster extension cases to transport fractures of the extremities and spine.

(5) The more generous use of brachial plexus block for injuries of the upper extremities.

(6) Two-thirds of all war wounds involve bones; hence the temptation of primary closure of these wounds in the advance station. Apparently, this has been abandoned in this war. However, the primary excision of these wounds, encasing them in plaster and holding them for 24 hours before evacuating to the rear, seems to be safe.

The chapter on Abdominal Wounds is one of the highlights in war surgery at the present time. His description of the manner of organization, the simple and yet complete instructions he has given in the handling of many conditions are arresting. The prognosis charts of Schmieden and Abadie are sections worth while.

JAMES B. MASON,
Major, Medical Corps, U.S.A.

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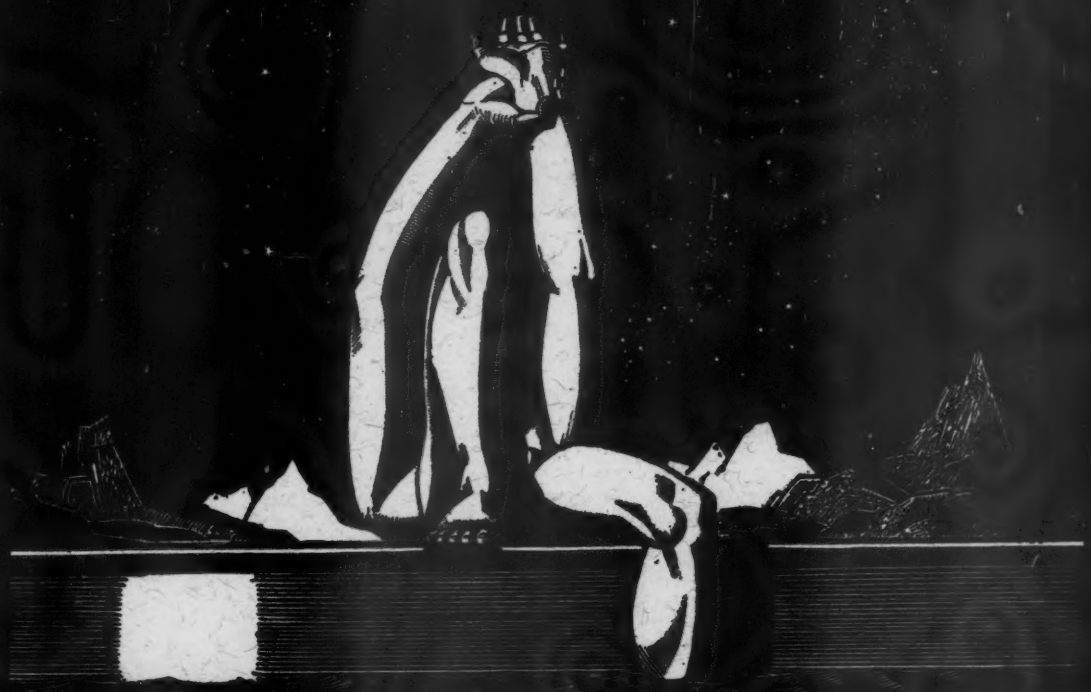

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